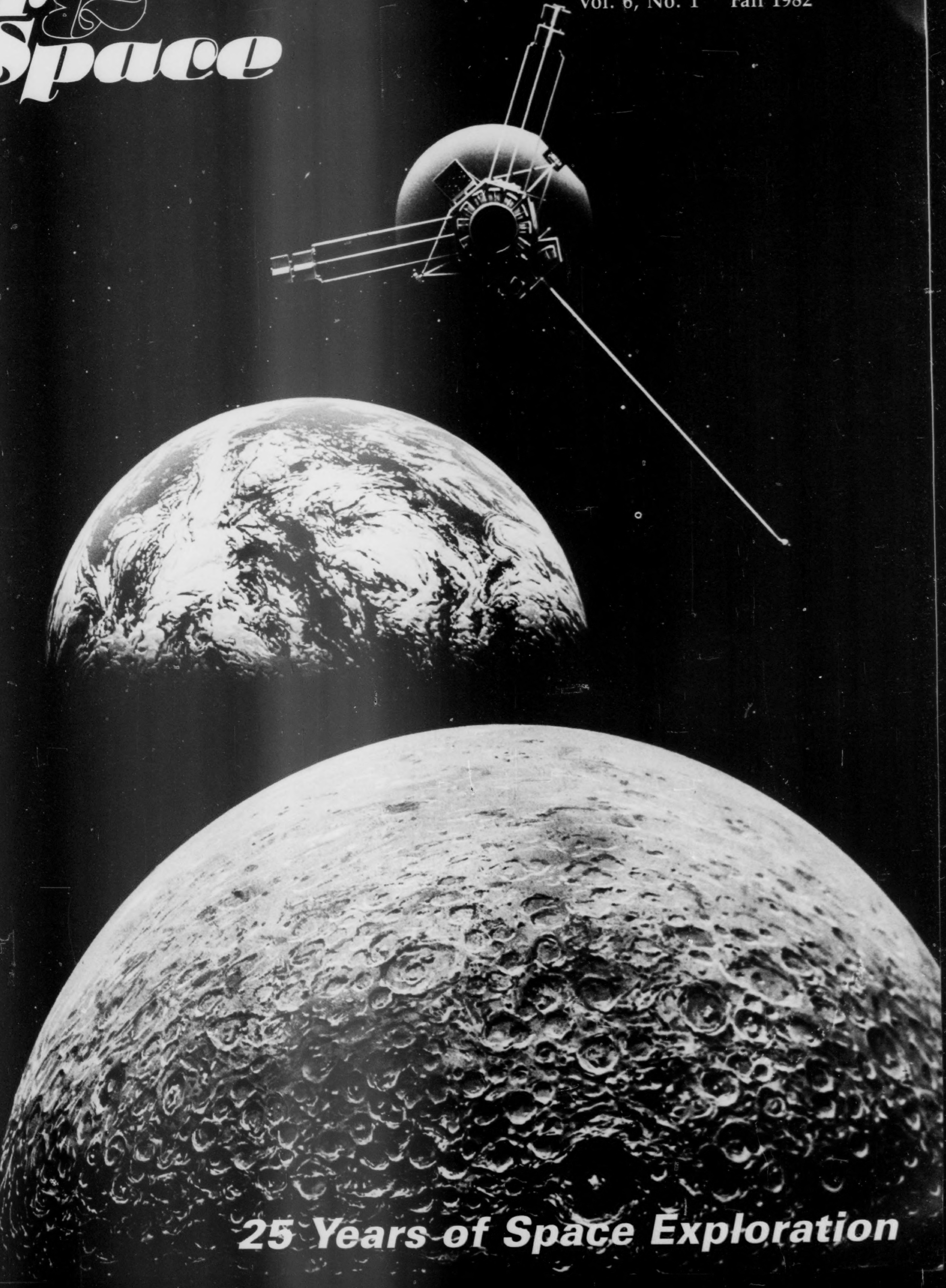
Air & Space

National Air & Space Museum
Smithsonian Institution

Vol. 6, No. 1 Fall 1982



25 Years of Space Exploration

Briefing

Walter J. Boyne
Acting Director, NASM

Perhaps the most satisfying aspect of museum work is seeing the past recreated in deft strokes. The museum research that results in exhibits is especially challenging because the past cannot be recreated in real time: one must sift through events and record those that will intrigue, instruct, and even entertain. In the process, one finds that there is more material than the exhibit can accommodate, and life becomes an agony of choosing. The Museum's most recent exhibit, "25 Years of Space Flight," is a remarkable example of this process. There has never been a 25-year period so filled with important scientific events, with unbelievable achievements, with so many occasions when human beings triumphed over distance, gravity, and hazard. Nor has there been a period so turbulent with social change, ranging from a vastly improved understanding of racial problems to the tyranny of trivia like Big Macs, Pac-Mans, and TV.

The curator of this exhibit had the almost impossible task of reducing these developments to an accurate, balanced story. The technical side is relatively easy, with the benchmark events of both the U.S. and Soviet programs definable as to date, time, relative importance, and degree of success or failure.

The social and cultural changes are more difficult to choose, particularly in an exhibit that must appeal to the public, and especially when many of the changes are charged with emotion. How does one portray the heady euphoria of the first months of the Kennedy administration, that nostalgic Camelot time, in conjunction with the numbing shock of his death and the turmoil that ensued? How does one give meaning to the reopening of relations with the Peoples' Republic of China by an administration that would eventually terminate in the Watergate disaster?

In a similar way, what is the best way to represent the true cultural level of the country at a time when it reached new heights and new depths? Can a country that is opening new theaters, sponsoring new ballet companies, and engaging in extensive international cultural exchanges also be one whose television fare started at a relatively low level and rapidly went downhill? Yes, obviously, but how do you tell that without somehow distorting the truth?

The answer, of course, is that the curator tries to evaluate each development and selects those that have the most dramatic—or sometimes comic—effect. It is mandatory that personal bias be suppressed to the maximum extent. The result of such an effort is often both satisfying and oddly disquieting. Such is the case with the current "25 Years of Space Flight." The exhibit comprises five major structures, each representing an element of time. Each has a six-minute videotape presentation that captures from film and television the magic moments of the period; and each case has artifacts, newspaper headlines, and graphics that reinforce the video presentation.

The first question on viewing the ensemble is "Did all of this happen in only 25 years?" and then "How did we live through it?" The answers are provided by the exhibit: yes, all this and more happened, and we lived through it because humans are extraordinarily resilient survivors who can participate in a pulsating series of shattering happenings and not only survive but thrive.

Perhaps the most important result of the exhibit, however, is to raise the issue of the next 25 years. Survival is obviously a genuine issue in the most catastrophic sense. Can we avoid war and achieve disarmament? Will there be the funding and the courage to carry on similar endeavors in space? Perhaps, the most hopeful answer is that no matter what the next 25 years hold, the human race will endure and, in all probability, flourish.

National Air and Space Museum
Walter J. Boyne, *Acting Director*

Education Services Division
Janet K. Wolfe, *Chief*

Air & Space
Linda S. DuBro, *Managing Editor*
Holly Haynes, *Design and layout*

Air & Space, a mini-magazine for educators, is published four times during the school year as an outreach of the National Air and Space Museum, Smithsonian Institution, Washington, D.C.

Air & Space combines information from many sources for a condensed overview of the history, science, technology, and social impact of selected aviation and space subjects.

Air & Space
Address all communications to: *Air & Space*, Room P-700, Education Services Division, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560. For changes or corrections of address, write to *Air & Space* at the above address, and include the 6-digit subscription number on your mailing label.

There is no charge for *Air & Space*. The magazine is not available by paid subscription.

Commercial interests and other publications wishing to reprint material should mail requests to the above address.

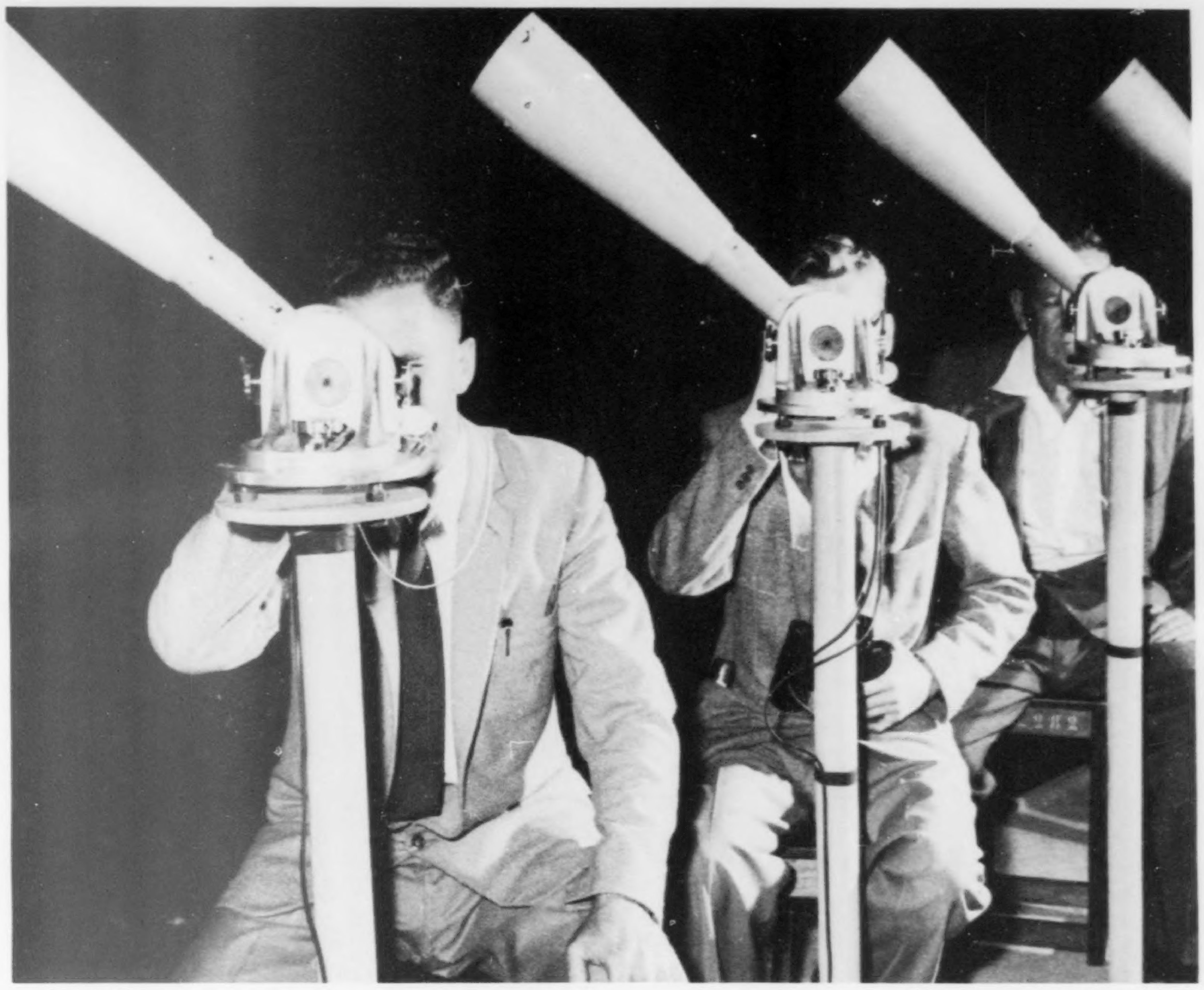
Back issues of *Air & Space* are available on microfiche or photocopy through University Microfilms International, Inc., 300 N. Zeeb Road, Ann Arbor, Michigan 48106.

MUSEUM HOURS
Through Labor Day (September 7), the Museum will be open 10 a.m. to 9 p.m. From September 8 to March 31, hours are 10 a.m. to 5:30 p.m. The Museum is open to the public every day of the year except Christmas. Admission is free.

For brevity, the National Air and Space Museum is often referred to in these pages as NASM. The National Aeronautics and Space Administration is NASA.

Cover Photo
Stylized view of Pioneer leaving the Earth and passing the Moon. Man reached out beyond Mars to take the first close look at the planet Jupiter on the mission of the unmanned Pioneer spacecraft, Pioneer 10, which can be viewed in NASM's *Milestones of Flight* *gallery, will be the first spacecraft to leave the Solar System this century.*

The Moonwatch Era Ends



Volunteer amateur and professional astronomers man a Moonwatch station in Pretoria, Africa. This worldwide volunteer satellite tracking network, established by the Smithsonian Astrophysical Observatory in 1956, produced the western world's first observations of Sputnik 1. During the first weeks of the space age, essentially all observational data from visual sources were supplied by Moonwatch teams. Moonwatch was disbanded in 1975 after some 400,000 observations of artificial satellites were made.

James Cornell
Publications Manager
Smithsonian Astrophysical Observatory

On June 30, 1975, Moonwatch, the volunteer international satellite tracking network, was disbanded after nearly two decades and some 400,000 observations of approximately 6000 artificial satellites.

The program grew out of the concerted scientific efforts surrounding the International Geophysical Year (IGY). In 1955 the National Academy of Sciences and the National Science Foundation asked the Smithsonian Astrophysical Observatory (SAO) in Cambridge, Massachusetts, to assume responsibility for the optical tracking of satellites launched by the United States during the IGY.

Fred L. Whipple, the Harvard astronomer who had been recently named director of SAO, proposed the development of a fast, large-aperture Schmidt optical system. Modeled after similar instruments used in Harvard's meteor program, it would be mechanized to follow the apparent motion of satellites across the sky.

The resulting camera was called the Baker-Nunn, after James G. Baker, who designed the super-Schmidt type optics, and Joseph Nunn, developer of the unusual triaxial mount and drive mechanism. Eventually, 12 of these instruments were manufactured and stationed around the world.

But Whipple also was convinced that the tracking could be done by amateur as well as professional astronomers. Thus he requested amateur astronomers to form a volunteer network to be called Moonwatch. The plan was for observing teams to locate satellites visually, thereby providing the raw data for more precise optical tracking by the cameras.

Planetarium inventor Armand Spitz, a special consultant to SAO, contacted many astronomy groups and developed operational procedures. In response, some 70 teams comprising 1500 volunteers were formed in the United States during the first few months.

Typically, a team set up a "fence" of observers using several wide-angle telescopes trained on the meridian at different altitudes. When an observer at one "picket" saw a satellite cross the meridian (defined by a crossbar on a vertical pole), he signaled the team's timekeeper, thus obtaining a fix on the object. The team leader then relayed the information to SAO. The techniques for precise timekeeping were worked out late in 1956. The rugged, simply constructed telescope was developed using designs of three program members.

The compact Moonwatch telescope had a 51-mm objective of 180-mm focal length; a wide-angle Erfle eyepiece of 32-mm focus gave a 6.8-degree field of view. These optics were mounted in an aluminum tube 21½-cm (8½-in.) long. An aluminized or silvered mirror was set at 45 degrees in front of the objective, permitting the observer to look downward from the horizontal and maintain the long sky watch in relative comfort.

Under optimum conditions, this 5⅔-power instrument could show objects down to 8th magnitude, and the wide field aided in finding a satellite even when its orbit was imprecisely known. To locate faint satellites, a few stations and individual observers later were equipped with 20-power modified M-17 elbow telescopes, each with a 120-mm lens and 2.4-degree field.

Because SAO could not afford to provide telescopes to all Moonwatch members, an estimated 40 percent built their own units, the optics cost only about $20 and were easily assembled in home workshops.

Test Operations Begin

The foregoing efforts were undertaken with a sense of urgency: both the United States and the Soviet Union were approaching the time to try sending a satellite aloft. The Vanguard project was to orbit a 20-cm (8-in.) "grapefruit;" the Department of Defense was working on an Explorer satellite; and the Russians were closing in behind a wall of secrecy.

By the spring of 1957, SAO had appointed a professional steering committee for Moonwatch—to provide scientific and technical advice. On May 17, 1957, Moonwatch held its first test alert. Six Civil Air Patrol planes flew over widely separated parts of the country, towing small lights to simulate satellites. That test and several others during the summer proved that the visual system could track the anticipated American satellites effectively.

By early October 1956, there were about 80 teams in the United States, 30 in Japan, and 10 each in Argentina and Germany. Thirty-three more teams were distributed among 15 other nations. By year's end, the network comprised 115 American and 90 foreign teams.

SAO had not planned to have Moonwatch fully operational until March 1958. However, when the Soviet Union launched Sputnik 1 on October 4, 1957, the network was able to make successful observations within a few days.

The first confirmed sightings were on October 8, 1957, from Moonwatch teams in Sydney and Woomera, Australia; the first American report came two days later from New Haven, Connecticut. For the initial weeks of the space age, essentially all observational data available outside the Soviet Union were provided by Moonwatch. By the end of 1957, the network had made about 700 observations of satellites.

When Sputnik 2 was launched, the first American sighting was made by the Moonwatch team in Tucson, Arizona, on November 5, 1957. The new object was widely seen on subsequent days.

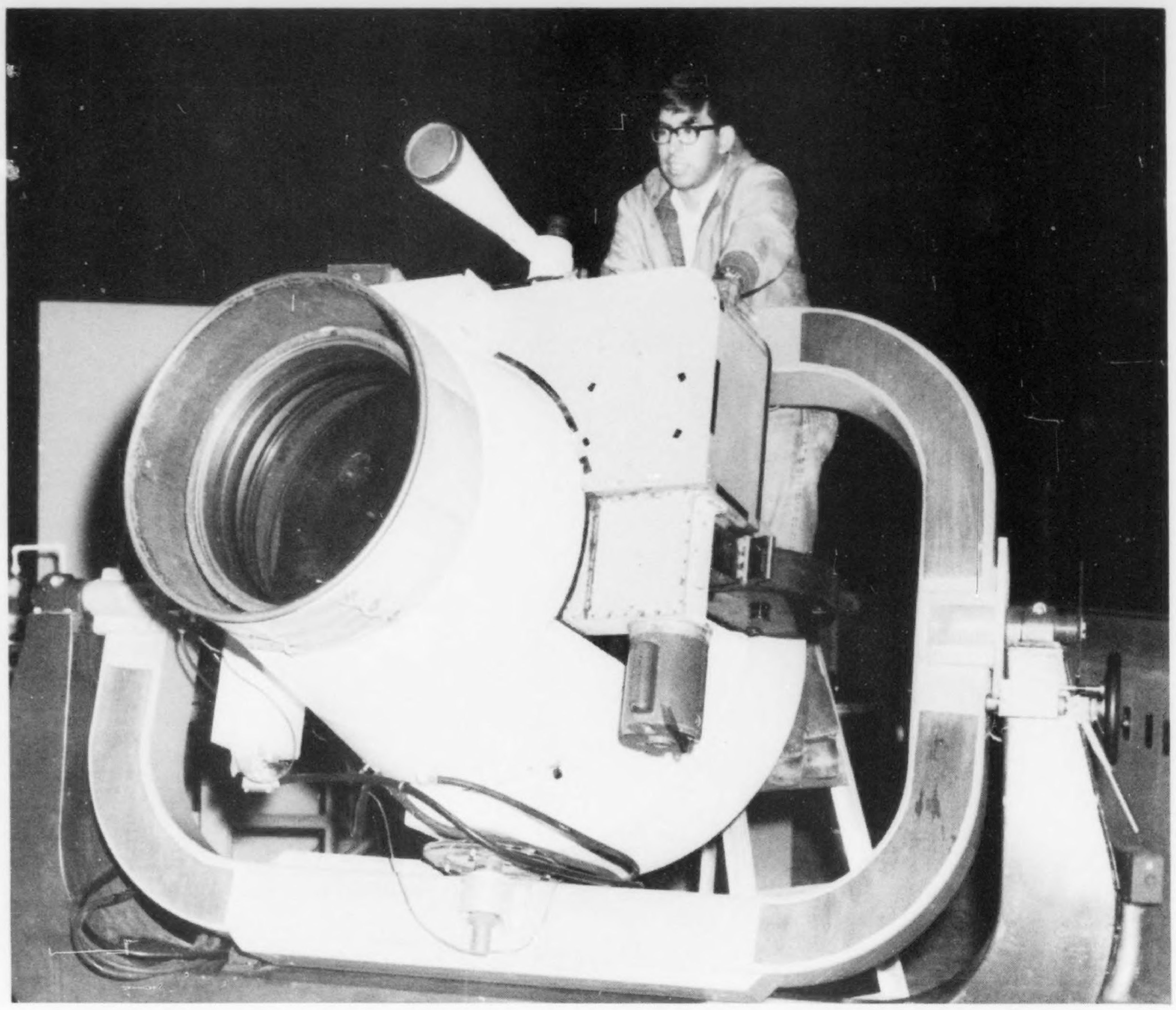
The first American launch success was on January 31, 1958, with the U.S. Army's launching of Explorer 1, whose fourth-stage rocket carried a 5-kg (11-lb.) scientific payload. The next evening Moonwatch observers at Alamogordo, New Mexico, spotted it, and on February 2, the Moonwatch team at Manhatten, Kansas, monitored three passages with a shortwave receiver. Thereafter, as more satellites were launched, the SAO observing programs achieved dramatic results. By the end of the first year of the space age, Moonwatch had obtained both visual and photographic observations of the first seven artificial satellites. Volunteers at 116 American stations and 122 abroad amassed 6816 visual observations, and the 12 Baker-Nunn cameras took 535 pictures.

The Years After IGY

Even after the IGY, Moonwatch and the Baker-Nunn network continued under SAO aegis with support from the then newly formed NASA. However, improved precision by ground-based radio, radar, and optical tracking systems significantly changed the program objectives.

A conference of team leaders in the early 1960s defined new goals. Along with the general improvement of orbit determination through greater positional and timing accuracy, the network would utilize its unusual qualities for several special projects.

The wide geographical distribution of the network teams also proved ideal for detecting the reentries of decaying satellites. The most spectacular success occurred in September 1962, when Moonwatchers in Milwaukee, Wisconsin, observed the reentry of Sputnik 4 and subsequently recovered some of the debris that fell onto a street in Manitowoc. The death of this 4500-kg (5-t) satellite, launched on May 15, 1960, had been predicted by the Air Force, and Moonwatch headquarters had notified 750 observers to be on the lookout for a fiery, spectacular descent.



This first of the Baker-Nunn cameras was set up in the Organ Mountains of New Mexico, where it recorded Sputnik 1 and Explorer 1. Now at the Smithsonian's Mt. Hopkins Observatory in Arizona, it acts primarily as a backup to the laser-ranging equipment for satellite tracking. Observer Joseph Delgado is seen in this photo by Dennis Milon.

In a similar effort, Moonwatch teams participated in the observation of bright meteors and the recovery of resultant fragments, including an 8-kg (18-lb.) meteorite that fell in Harleton, Texas, in 1961.

In support of the reentry and meteor programs, Herbert Roth, a Moonwatcher employed by United Airlines, established in 1963 informal reporting procedures for United's flight personnel to gather data on objects seen from the air. In 1969, his group was incorporated into the Volunteer Flight Officers Network, which eventually involved observers from 120 airlines around the world. About 4200 observations were made between 1963 and 1975 by flight personnel.

Although originally intended to operate for only 18 months, Moonwatch provided valuable aid to the national space program for over 18 years. Most extraordinary, perhaps, was the persistence and dedication of its members, despite the arduous, time-consuming work, with little reward other than participation in astronomically oriented research.

Moonwatch remained viable and productive to the end. One hundred active teams still existed around the world in June 1975. Another 60 inactive groups could be mobilized for special projects, and up to 100 major observatories often participated in network emergency alerts.

Obviously, Whipple's original conviction about the value of amateur astronomers had been correct, despite predictions to the contrary by the military and other government agencies. Furthermore, although involving over 5000 individuals, Moonwatch was probably the least expensive operation of the space program. Officials have estimated that the 400,000 observations may have been worth more than $14 million when compared to the cost of other tracking systems such as Minitrack.

Other benefits of the Moonwatch program included significant contributions to public understanding of science and satellite tracking in the first hectic and somewhat alarming days of the Sputniks. Moonwatch also contributed to an international appreciation of American space programs, and many younger members of the original teams, introduced to space science in this direct way, went on to careers in astronomy, astrophysics, and related fields. ■

Related Flight series filmstrip: *Satellites* (see back cover).

The Decision to Go to the Moon

Apollo 17's crew consisted of Commander Eugene A. Cernan, Command Module Pilot Ronald E. Evans, and Lunar Module Pilot Harrison H. Schmitt. Astronaut Schmitt's photo is reflected in the gold visor of Astronaut Cernan.

John M. Logsdon
Director, Graduate Program
Science Technology and Public Policy
George Washington University

It has been almost ten years since the last two of the twelve U.S. lunar explorers, Gene Cernan and Harrison "Jack" Schmitt, left the surface of the Moon. There are no current plans for returning. Sometimes it seems as if Apollo happened much longer than a decade ago; the command modules, LEMs, and gigantic Saturn V boosters are already museum pieces, and the facilities at Cape Canaveral are now being used for launching the space shuttle. It is fashionable, even among space supporters, to dismiss Apollo as only a politically motivated stunt, having little to do with the "real" meaning of space, which is linked to unmanned science and exploration and to using humans as orbital workers in exploiting the benefits of near-Earth space.

And yet—men did travel through outer space to another celestial body. In the broad sweep of history, this first hesitant step off our home planet is not likely to be forgotten.

How did Apollo happen? In today's debates over government budgets and the proper goals of the U.S. space program, it seems almost inconceivable that just 21 years ago an American President stood before a joint session of Congress and said:

> Now is the time to take longer strides—time for a great new American enterprise—time for this nation to take a clearly leading role in space achievement, which in many ways may hold the key to our future on Earth.
>
> I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth.
>
> I believe we should go to the Moon.
>
> —John F. Kennedy,
> May 25, 1961.

Origins of Apollo

Kennedy's words capped six weeks of intensive debate over U.S. space policy, and they reflected a reversal of President Eisenhower's policy, adopted after Sputnik, of calm conservatism with respect to using space achievements as symbols of political competition. Eisenhower gave strong support to scientific and military uses of space, but he was unwilling to enter a space race with the Soviet Union, particularly one involving humans.

The immediate stimulus to Apollo was the April 12, 1961, one-orbit flight of Cosmonaut Yuri Gagarin, the first man in space. The Soviet Union was quick to capitalize on the propaganda significance of Gagarin's flight. Nikita Krushchev, talking to Gagarin while he was still in orbit, boasted, "Let the capitalist countries catch up with our country!" But Soviet self-congratulation was not particularly necessary. The world was almost unanimous in admiration; even the Vatican newspaper called the flight "a universal good."

Just a few weeks earlier, Kennedy had rejected immediate acceleration of the U.S. space effort. He was new in office and wanted more time to develop his space policy. After Gagarin's flight, Kennedy became convinced that the United States should not take second place to anyone, particularly to the Soviet Union, in the critical area of human activity. Kennedy's science advisor Jerome Weisner remembers that the President "became convinced that space was the symbol of the 20th century. It was a decision he made cold-bloodedly. He thought it was right for the country."

Most major policy decisions in the U.S. government are made in response to some "action-forcing stimulus"—to a crisis. We tend to react and to solve problems once they become apparent; so it was with space. Gagarin's flight made clear the political importance of space achievement in terms of prestige among nations and pride and self-image within this country. The political problems of the United States were compounded when, in the week following the Soviet accomplishment, a group of U.S.-trained Cuban refugees attempted, at the Bay of Pigs, to invade Cuba and to overthrow the Castro government. By April 19, Castro had crushed the invasion as the United States stood by, unwilling to intervene on behalf of its protégés.

The Cuban fiasco reinforced Kennedy's resolve to proceed rapidly in space. On April 20, the President requested Vice-President Johnson to conduct a rapid review of where the United States stood in space, and he asked the question that led directly to Apollo:

> Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the Moon, or by a rocket to land on the Moon, or by a rocket to go to the Moon and back with a man? Is there any other space program which promises dramatic results in which we could win?

Plans for a Lunar Mission

"Is there any other space program which promises dramatic results in which we could win?" Kennedy had placed the United States in the space race, and his technical advisors had little difficulty in providing him a winning entry, one which reflected an assessment of technical feasibility and embodied the dreams of centuries. Over two years earlier, NASA planners, thinking beyond the initial programs the new agency had inherited, had chosen a manned lunar mission as the appropriate long-range goal for the U.S. space program and for months had been studying ways of accomplishing it. They could respond to Kennedy's question with assurance that sending men to the Moon was technically feasible. Moreover, both the Soviets and the United States would have to develop a new large-booster rocket to accomplish a lunar landing mission, and so the two countries would be starting out fairly even in the race to the Moon. Kennedy was given 50-50 odds that the United States could successfully get men to the Moon and back before the Soviets, and he decided to accept those odds. One reason for taking such risks was a belief that a lunar landing program, as the centerpiece of a fast-paced U.S. space effort, was worth doing on its own merits, whether or not it resulted in beating the Soviets. For centuries, travel to the Moon had been a central image of all who had thought seriously about space exploration; a lunar mission was likely to create the broad public support needed to make an accelerated space program practically feasible. As mentioned earlier, NASA engineers had chosen a lunar journey as the focus for its manned space efforts of the '60s and '70s well before Kennedy had entered the White House, mainly because it provided the kind of specific objective required to focus the development of space technology.

The recommendations to Kennedy that formed Apollo's charter clearly stated the motives for the lunar landing thrust. NASA Administrator James Webb, Secretary of Defense Robert McNamara, and Vice-President Johnson summed them up in a few sentences:

> It is man, not merely machines, in space that captures the imagination of the world. All large-scale projects require the mobilization of resources on a national scale. They require the development and successful application of the most advanced technologies. Dramatic achievements in space therefore symbolize the technological power and organizing capacity of a nation. It is for reasons such as these that major achievements in space contribute to national prestige.

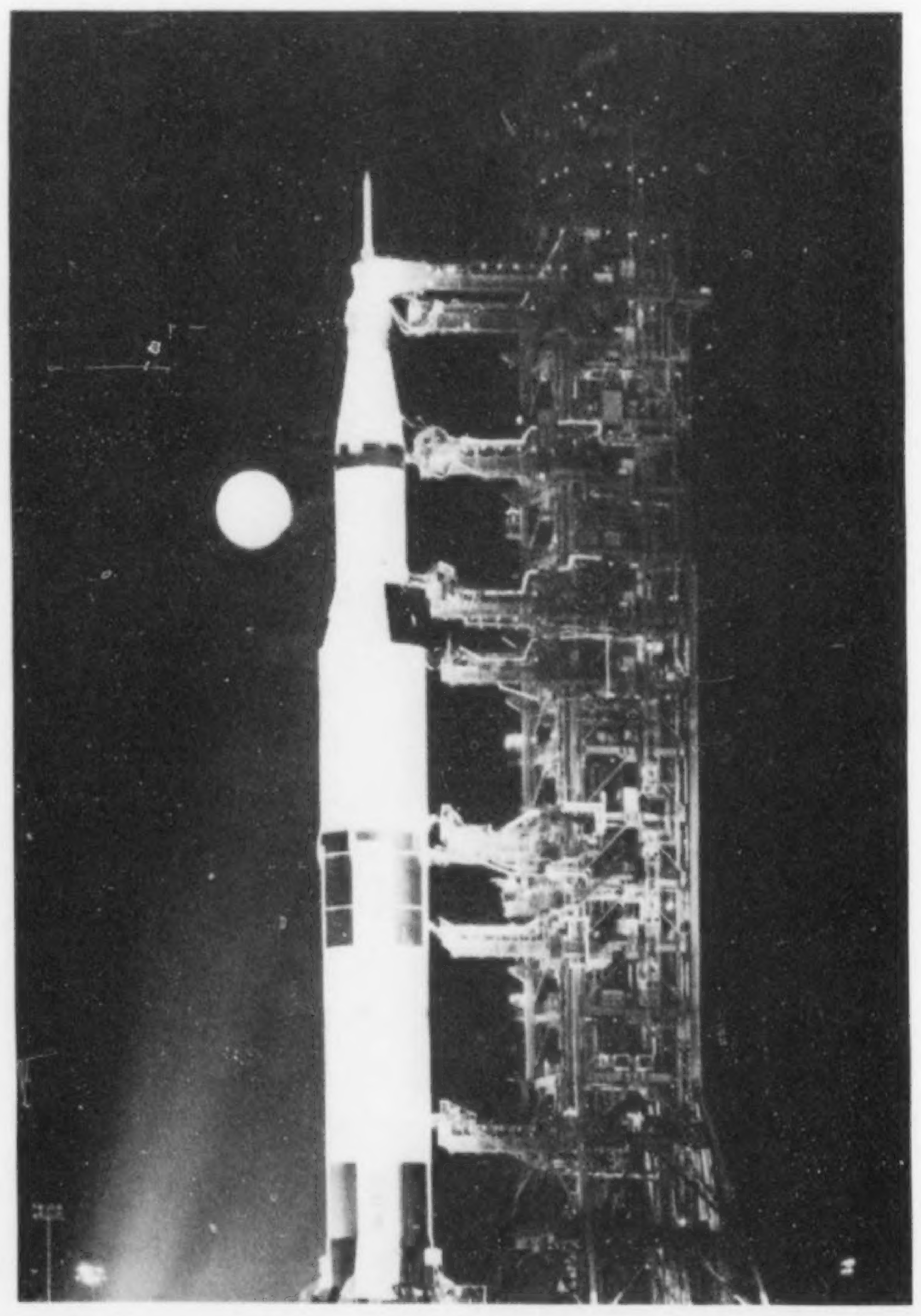
Space achievements developed prestige, they asserted, in the power struggle between the United States and the Soviet Union; the United States should thus undertake a manned mission to the Moon, even if the scientific or military grounds were lacking:

> Major successes, such as orbiting a man as the Soviets have just done, lend national prestige even though the scientific, commercial, or military value of the undertaking may by ordinary standards be marginal or economically unjustified. . . . Our attainments are a major element in the international competition between the Soviet system and our own. The non-military, noncommercial but "civilian" projects such as lunar and planetary exploration are, in this sense, part of the battle along the fluid front of the cold war.

Apollo Evaluated

As the last sentence suggests, Kennedy's commitment to Apollo was a decision set in the context of the Cold War of the 1950s; it reflected a view of a world in which U.S.-Soviet competition was a dominant reality, and where each side had a vital stake in staying ahead of the other in political and military power. Apollo was intended to represent to the world and to ourselves an image of the strength and vitality of the American nation.

Apollo 17, the final mission to the Moon was the first manned launch made at night. Apollo 17 was launched December 7, 1972, from Kennedy Space Center, Florida.



With the peaceful resolution of the Cuban Missile Crisis in 1962, the Cold War gave way to detente, and space competition lost much of its symbolic impact. Kennedy could anticipate none of this when he made the Apollo decision. In 1961, Apollo looked like a good and necessary investment in the nation's future. On the whole, Apollo's political objectives were achieved; the lunar program, even in the very changed context of the late '60s and early '70s, was viewed by the world as a remarkable human achievement, one reflecting great credit on the nation that had accomplished it.

Apollo was also the central project in an accelerated and integrated national space effort in the scientific, commercial, and military areas. Without such a focus, the United States probably would have made far less progress in learning how to operate in space. Most people support the U.S. space program because its exploratory efforts, particularly those with human crews, satisfy emotional and psychological needs. Since Apollo, we have largely lacked such a focus; Apollo created the context within which the space program could be oriented toward unmanned exploration and Earth-oriented applications. If we had not gone to the Moon, we would still be debating whether we should go, rather than discussing other space goals.

The commitment to Apollo was very much a product of a specific time, a specific situation, and specific individuals in key positions. Today's leaders appear far less convinced than was John F. Kennedy that the space program is a good investment of major national resources. Until such a conviction appears, another undertaking like Apollo is unlikely to emerge. Looking back from the perspective of more than two decades on what made Apollo possible, it seems as if we are not going to see its like for some time to come. ■

Reference

Quotations are taken from Logsdon, John M. *The Decision to Go to the Moon: Project Apollo and the National Interest.* Cambridge: MIT Press, 1970.

Related Flight series filmstrip: *Rocketry and Space Flight* and *Apollo to the Moon* (see back cover).

Reflections of an Apollo 11 Astronaut

Michael Collins
Vice-President, Washington Operations
Vought Corporation

Apollo 11 Command Module Pilot Michael Collins during suiting-up a few hours before he and astronauts Neil A. Armstrong and Edwin E. Aldrin, Jr., were launched on the nation's first manned lunar landing mission. Liftoff of the Apollo/Saturn V took place at 9:32 a.m., July 16, 1969, from Kennedy Space Center, Florida.

Prior to deciding to send a man to the Moon, President Kennedy had been advised that it was technologically feasible to do so. However, that opinion was far from unanimous, and there were experts in many fields who felt that the unknowns of space (and the Moon) might prevent a successful landing or return to Earth. For example, as late as mid-1969, a week or so before the launch of Apollo 11, I was warned by a concerned NASA co-worker that there was an excellent chance that pure metallic elements from the Moon's surface clinging to the boots of Armstrong and Aldrin would spontaneously burst into flame when exposed to the 100 percent oxygen environment of the lunar lander's cabin.

Such extreme notions were easy to dispel, but in the early 1960s there were other doubts serious enough that NASA decided it could not prudently proceed directly to a lunar landing attempt (Project Apollo) without some intermediate space experience. Thus Project Gemini was born, and that is when I entered the space program, at the beginning of 1964. By that time the six flights of Project Mercury (Shepard, Glenn, Grissom, Carpenter, Schirra, Cooper) had proved that people could survive in space. The Mercury astronauts were not zapped by meteorites nor sickened by radiation. In weightlessness, they could swallow normally; their hearts did not stop; and their gastrointestinal systems worked just fine. But the doctors felt that there was a world—or at least a planet—of difference between Mercury's short flights in Earth orbit and the eight days for a minimum duration lunar landing mission. The engineers had their concerns as well, primary among them the difficulty one spacecraft might encounter in finding its sister ship in the vastness of space, and then successfully rendezvousing and docking with it. The Apollo lunar landing scheme centered around a rendezvous in lunar orbit between the lunar module (after its ascent from the lunar surface) and the command module, which was parked in lunar orbit and which returned all three crew members to Earth. No rendezvous: two dead men, maybe three. The engineers were also concerned about their ability to design equipment to allow men to work outside a spacecraft in a vacuum where the temperature could range from +120°C to −120°C (+250°F to −250°F).

This last point was secondary, perhaps even trivial, compared to the first two (physiology, rendezvous), which were the real imperatives of the Gemini program. As astronauts we tended to be very optimistic about the ability of our bodies to withstand the rigors of space—the long, weightless free fall followed by a jarring reentry into the atmosphere, where deceleration to landing speed could cause us to weigh ten times our normal weight (we practiced on the centrifuge to 15G).

We were less confident of our ability to rendezvous. As pilots we all knew the difficulty of seeing a small object, such as a fighter plane, in the distant sky, and the Apollo command module was certainly no larger a target. Instruments helped, sure—and radar, and computers—but these gadgets also broke, fairly regularly it seemed to us, and then what? The Apollo rendezvous must be 100 percent successful. Back-up procedures needed to be worked out and optimum techniques developed. Was rendezvous in sunlight, with the target clearly illuminated, better than a night rendezvous, with the star background acting as a reference grid? Did one approach from above or below? Was it smarter to overtake slowly, trading time and fuel for caution, or to be bold and intercept swiftly? Could roles be reversed and the hunted become the hunter? All of these were reasonable questions; however, as Gemini began there were no informed answers.

Between March 1965 and November 1966, ten manned-Gemini flights were successfully completed. Gemini III (Gemini I and II had been unmanned test shots) was a routine first flight—if any first flight can be called routine—by Gus Grissom and John Young. Two years later Gus, as Commander of the first manned Apollo flight died in a fire inside his spacecraft on a Cape Kennedy launch pad. Seventeen years later, John Young is still an active astronaut, having flown two Gemini and two Apollo flights, and the first shuttle orbital flight—more trips into space than any other astronaut.

The Gemini IV spacecraft can be found today in NASM's Milestones of Flight Gallery, and it's worth a close look at this miniature two-seater. Imagine Ed White, 5'11", wide-shouldered and encumbered by a bulky, rigid pressure suit, taking a space walk and then shoehorning himself back into that tiny seat while Jim McDivitt, strapped in tightly and unable to close the hatch himself, looked on helplessly. It was an exercise requiring great strength and agility; fortunately Ed had plenty of both (he later ended up with Grissom in the Apollo fire).

Gemini V (Cooper, Conrad) doubled Gemini IV's four-day endurance record while Gemini VII (Borman, Lovell) lasted 14 days, more than enough for a trip to the Moon and back. Before and after the flights, x-rays of the various crews' heel bones revealed that enough calcium had been lost to cause concern for a human's ability to stay in space indefinitely, and noticeable cardiovascular deconditioning lingered for a couple of days post flight. But even the most pessimistic doctors agreed that the coast was clear, at least from a physiological point of view.

Gemini VI (Schirra, Stafford) was the first rendezvous flight using Gemini VII as a target. Gemini VIII (Armstrong, Scott) was the first to dock at the completion of its rendezvous, with a specially prepared Agena target vehicle. Gemini IX (Stafford, Cernan) was another rendezvous flight as well as our country's second experience with a space walk.

Gemini X (Young, Collins) was a three-day flight with a slightly new twist. We had two Agenas to work with: our own, fully fueled, plus an inert one in higher orbit left over from Gemini VIII. The idea was to rendezvous and dock with ours first and then use its power to propel us into the higher orbit to catch the old Agena and retrieve from it a micrometeorite experiment package. Fortunately, we got all this done—in the three busiest, most hectic days of my life. But we used more fuel in the process than we should have, and some of our activities had to be curtailed because of it.

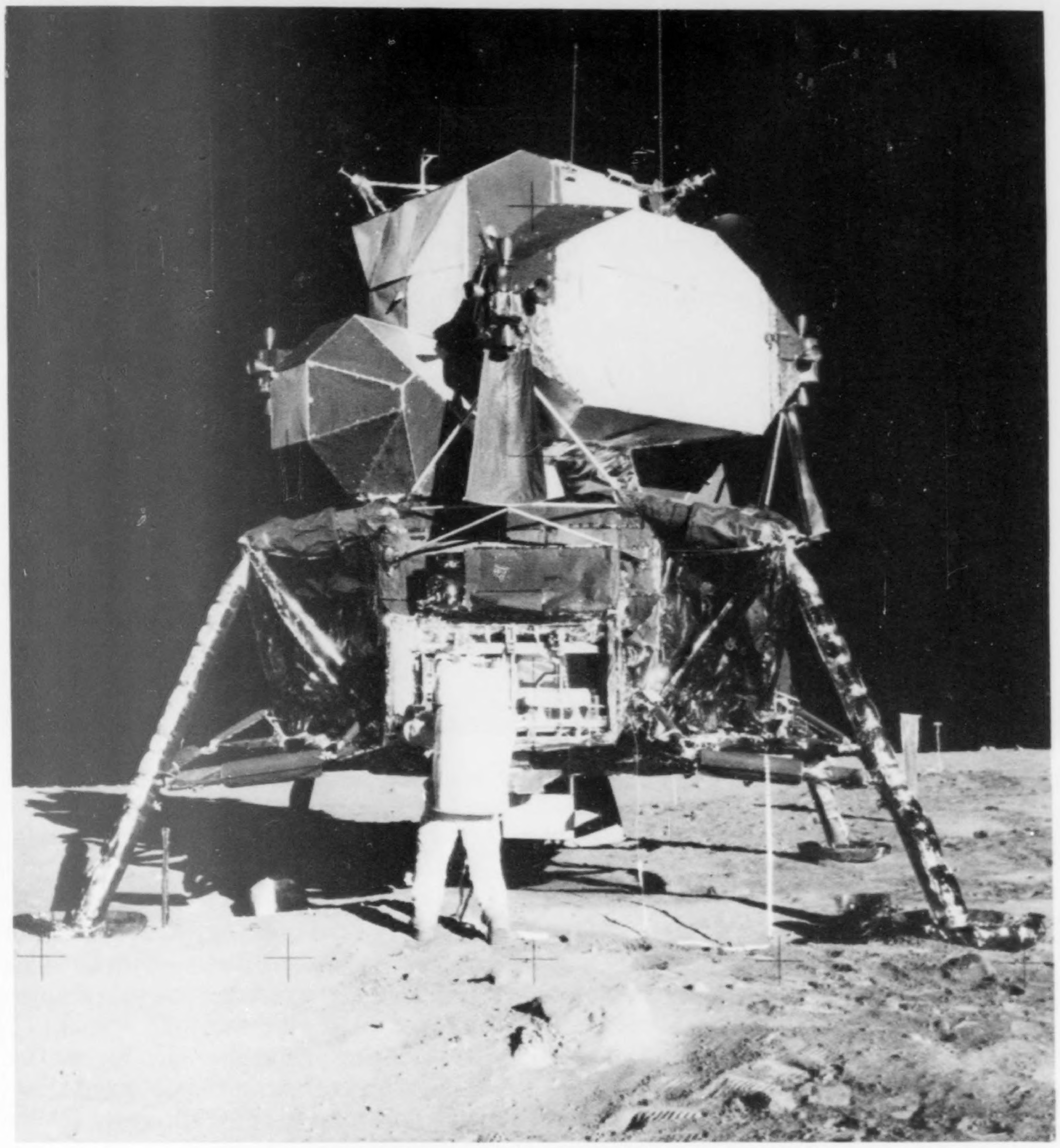
No Gemini flight had used the Agena's engine before, so John and I were curious as to what to expect. It was a little different in that the Agena was plugged into our nose, and its rocket motor was mounted on its far end so that it would be kicking us backwards. When I threw its ignition switch, nothing happened for a second, and then it began to cough out globs of propellant, which in reflected sunlight looked like large golden snowballs zinging off into the darkness. "Pretty," I thought, "but it's not going to light." Just then the whole sky seemed to explode in an orange flash; I was jerked forward and plastered against my shoulder straps. In only 14 seconds, the Agena's thrust added enough energy to our orbit to cause our apogee, or high point, to reach nearly 800 km (500 mi.)—a world's altitude record.

Our second rendezvous was different because we had no radar to help us. Our Gemini radar was working OK, but it required an answering voice (transponder) on board its target, and the Gemini VIII Agena had long since run out of electrical power. Therefore we had to depend entirely on optical data, which meant that we used a sextant to measure the angle between the Agena and us. By calculating its rate of change we got a rough estimate of whether our approach path was correct or not. Then when we got close, we had to rely on our eyes, or eyeballs as pilots like to call them, instead of our radar to tell us when to slow down. It was tricky, but it was both good practice for Apollo and worked out well—thanks to John's good eyeballs.

The Apollo 11 Saturn V space vehicle carrying Astronauts Neil A. Armstrong, Michael Collins, and Edwin E. Aldrin, Jr., lifted off at 9:32 a.m., July 16, 1969, from the Kennedy Space Center. Armstrong and Aldrin explored the Moon's surface while Collins piloted the command module in lunar orbit. " . . . I felt drawn to Earth . . Earth truly is fragile . . . "—Michael Collins.

We did not plan to dock with this Agena since it might have been tumbling out of control. Instead, while John was flying in formation with it, I made a short space walk over to it to retrieve the experiment package. I think this was the most exciting thing I have ever done, not as important as flying to the Moon, but a more spectacular, adrenalin-pumping exercise I cannot imagine. At one point I lost my grip on the Agena and slipped off, tumbling helplessly on the end of a 15-m (50-ft.) tether that I desperately hoped would not become ensnarled with the Agena or looped around the Gemini, neither of which were in my view. Only friendly old Earth occasionally spun across my faceplate. Finally I got things under control, wedged myself and the package back inside the cockpit, and John and I were off to slightly saner endeavors.

Gemini XI (Conrad, Gordon) broke—almost doubled—our altitude record and, like Gemini XII (Lovell, Aldrin), ran some variations on the rendezvous and spacewalk themes. These rendezvous exercises in Earth orbit were invaluable preparation for Apollo and were the technological highlights of the Gemini program. But from a human point of view it was Frank Borman and Jim Lovell, crammed for *two solid weeks* into an enclosure considerably smaller than the front seat of a VW bug, that commanded my respect.



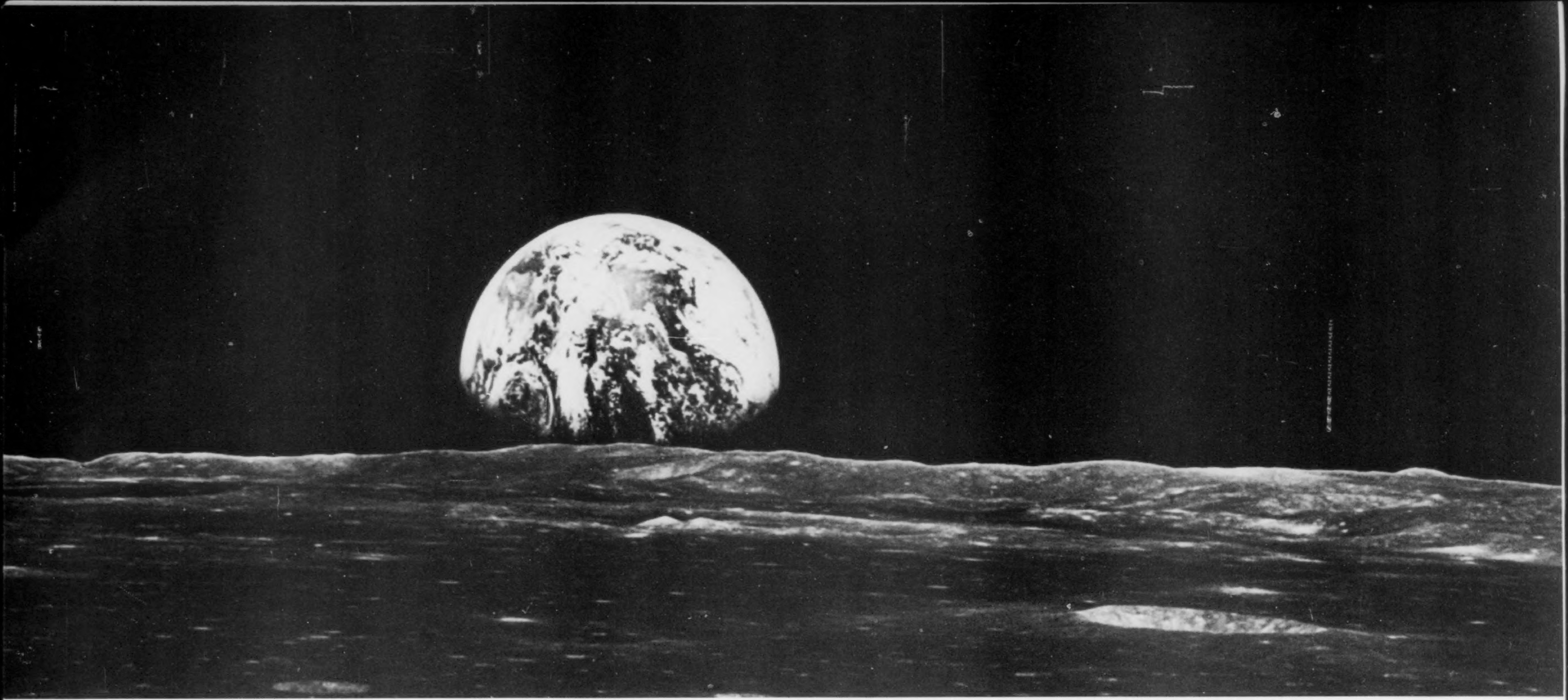
Lunar Module Pilot Edwin E. Aldrin, Jr., prepares to deploy the Early Apollo Scientific Experiments Package (EASEP) during the Apollo 11 lunar surface extravehicular activity. Commander Neil A. Armstrong took this photo of Aldrin removing the EASEP from its stowed position.

The Apollo program got off to a dismal start because of the fire early in 1967 that killed Grissom, White, and Roger Chaffee. The Apollo spacecraft, like its Mercury and Gemini predecessors, was filled with 100 percent oxygen at 5 pounds per square inch (psi) pressure in space, but on the launch pad, the pressure went up to 15 psi. Materials in a pure oxygen atmosphere at this pressure are extremely flammable, and this fact coupled with a poorly designed hatch, lead to this fatal accident. No matter how many talented people are involved and no matter how hard they try to think of every eventuality, in a new venture something unforseen frequently happens. Test pilots know this, but it doesn't make it any easier when you have to tell a friend's wife why her husband won't be coming home anymore.

A new hatch design and a new gas mixture on the pad enabled us to get on with the program, but it wasn't until the summer of 1968 that Schirra, Eisile, and Cunningham finally got Apollo 7 off the ground. It was an 11-day flight in Earth orbit—the first flight of the command module—but without a lunar module. It was an amazingly fault-free first flight for a piece of equipment as complicated as the command module (perhaps the accident and the subsequent delay had provided an extra margin of safety for the rest of us). It gave the program managers sufficient confidence to commit the second flight, again with the command module along, to go all the way to lunar orbit. The Apollo 8 crew members, Borman, Lovell, and Anders, were the first humans to escape Earth's gravitational field, an achievement that I think will be considered as important by future historians as the first landing on the Moon, especially after space travel becomes well established. It was a very gutsy decision, to risk three men 370,000 km (230,000 mi.) away from home on the second Apollo flight. And probably more than any other single decision, it allowed us to meet the President's deadline of landing on the Moon by the end of the decade. On Christmas Eve of 1968, Borman and company were reading from the Book of Genesis from the Moon, but there was still a tremendous amount of work to be done.

The lunar module tested its wings on the next two flights. First, Apollo 9 (McDivitt, Scott, Schweickart) proved the flight worthiness of the lunar module in Earth orbit and further demonstrated that a rendezvous between the command module and the lunar module was not only possible but easy, at least under carefully controlled conditions. The next flight, Apollo 10 (Stafford, Young, Cernan) was the last preliminary before the main event—a dress rehearsal in lunar orbit during which the lunar module skimmed down close to the surface before climbing up again to rendezvous with the command module. The equipment and procedures had worked so well during all four preliminary flights that the decision was made to launch Apollo 11 in July and to attempt a landing.

I say "attempt" because it was far from a sure thing, at least in my mind. I figured the chances were about 50-50 for a successful landing and return. Maybe I'd spent too much time in the simulator practicing emergency procedures, but I felt that with so many things that could go wrong, something probably would. I discussed this with Neil Armstrong and Buzz Aldrin after the flight and discovered that they had been much more optimistic than I, and of course they were right. But an Apollo flight to the Moon and back is a complicated sequence of key events, a long and fragile daisy chain that can easily be broken. Which link is the weak one? In April 1970, when Apollo 13 had an oxygen tank explode and not only failed to land



This view of the rising Earth greeted the Apollo 11 astronauts as they came from behind the Moon after the lunar orbit insertion burn. Earth is just above the lunar horizon in this photograph. The unnamed surface features [foreground] are near the eastern limb of the Moon as viewed from the Earth, which is 240,000 statute miles away.

but barely managed to limp home, I was not surprised that something like that could happen, but only that it had not happened sooner. I think the NASA Administrator, Tom Paine, was a little concerned about the crew of Apollo 11—that in our zeal to be the first to land, we might take some foolish chances. He flew from Washington to Cape Kennedy shortly before launch and assured us that if we came back without having landed, we would be given another shot at it on the very next flight. That was a smart thing for him to do, because it took a lot of pressure off us, especially Neil, who would be making a last minute decision on whether to land or not.

As the world knows, Apollo 11 did land successfully, in the Sea of Tranquility, just 1° north and 23° east of the Moon's center, on July 20, 1969. Neil overflew a boulder field and found a flat spot with just ten seconds of fuel remaining. Circling the Moon by myself in the command module, I was as thrilled as anyone else that they had gotten down safely. But perhaps more than anyone else I was also keenly aware that the flight was just half over, perhaps not even half if one considered the links of the daisy chain that still could be ripped apart. The biggest hurdle, in my mind, was the rendezvous, followed by the single rocket-engine firing that would send us back to Earth, followed by the 40,000-km/hr (25,000-mph) dive back into the atmosphere, followed by the opening of three (please, at least two) parachutes. The point of highest excitement for me was at the completion of rendezvous and docking when I could stop worrying about abandoning Neil and Buzz on the surface or in some lopsided orbit that my command module could not reach. From then on, gravitationally and emotionally, it was all down hill.

A dozen years after the flight, my recollections of many details have dimmed considerably, but I'll never forget the extraordinary twin views of the big Moon and the small Earth—and the contrast between the two. The Moon up close has a certain rugged grandeur, but unless you are a geologist intrigued by the variety of craters and rock formations, it is basically a monotonous place, devoid of the delightful surprises that spoil us Earthlings. I keep two Moons in my inventory these days, the one over the back fence and the one up-close. They seem like two separate places, although occasionally while eyeing the former I'll come to with a jolt and say "Hey, I've been there!" But I can honestly say I don't miss the place, and I'll give my return ticket to someone else.

The distant Earth view is another matter. Seeing home a little over one light second away is a profound experience. On Apollo 11 we were required to position our spacecraft broadside to the Sun and then rotate, like a chicken on a spit, so that no part of our machinery would get too hot or too cold. In this alignment the Earth was generally not even in sight, so that it was a rare treat when it came into view. In the early days of the space program some psychologists had predicted a "break away" phenomenon, similar to the diver's rapture of the deep, wherein an astronaut would want to keep going farther and farther away from Earth. I found precisely the opposite effect. I felt drawn to Earth as though powerful magnets were attached to my body and Earth was a steel ball. Not that it seemed made of steel, except that it looked smoother and polished. It was blue and white marble, cool and utterly silent, small as a thumbnail as it drifted lazily across our window. This tiny beacon gleamed in the sunlight with four times the brilliance of a full Moon. It was hard to take my eyes off it. It was a soothing sight—a serene presence—inviting us home.

But beyond all that, Earth projected most strongly a feeling of fragility. It seemed to be a place requiring great care, a place to be nurtured and coddled, not set on fire. This feeling persists after 12 years. Earth truly is fragile; its flora and fauna terribly susceptible to destruction; its soil, seas, and sky subject to thoughtless and irreversible damage. How many styrofoam cups can the Sargasso Sea accommodate? The detritus from our industrial triumphs may in the long run be tragic monuments to the failure of our civilization, if we don't bomb ourselves into extinction in the meantime. Yet our technology, if properly harnessed, can definitely find solutions equally beneficial to the planet itself and to its inhabitants. It's the only Earth we have, certainly the gem of this Solar System, to which photographs of Mercury, Venus, Mars, Jupiter, and Saturn attest. We *must* learn to do a better job of caring for it. ■

Related Flight series filmstrip: *Apollo to the Moon* and *Space Flight and Human Survival* (see back cover).

Unmanned Spacecraft: 25 Years Listening And Learning

Allan Needell, Associate Curator
Department of Space Science and Exploration, NASM

The extension of the senses beyond their natural limits represents an essential aspect of the advance of our ability to understand the physical universe. One of the most significant contributing factors to the scientific revolution of the 17th century was the gradual acceptance of evidence provided by newly invented devices such as the telescope and the microscope. Whole new worlds were opened to study and understanding; and as a result, discoveries in astronomy, biology, and many other branches of science followed rapidly one upon the other. Today, sophisticated observing and measuring instruments continue to provide the opportunity for new and important discoveries as well as the means to carefully test existing theories and ideas.

Twenty-five years ago, through the advance of rockets and electronics, we once again provided ourselves with the means to drastically extend our senses. This time the improvement was not a new way of amplifying or magnifying the things that we could see but rather the development of artificial "eyes" and "ears" and the capacity of placing them outside Earth's atmosphere. Used for centuries for amusement and as implements of war, about 25 years ago rockets started to launch instruments into orbit around Earth. A few years later, more advanced rockets placed similar devices into orbit around the Sun, and to the neighborhoods and then the surfaces of Venus and Mars. Radios enabled the satellites and space probes to relay their observations back to anxious scientists on Earth.

Who has not been impressed by the most recent accomplishments (the awe inspiring views of the rings and satellites of Saturn returned by the U.S. spacecraft Voyager II and the pictures of the surface of Venus returned by the Soviet Union's Venera spacecraft)? The creation of remote-controlled observers to explore worlds hitherto hidden from our scrutiny represents the continuation of an old and important human tradition—the design, fabrication, and use of special tools to answer questions about the nature of the universe in which we live.

In the United States, rockets and radios have extended our senses for about 35 years. Following World War II, scientists were anxious to place scientific instruments on board some of the German V-2 rockets that were captured after the war. The army responded favorably to the scientists' requests, allowing them to participate in the V-2 testing program. As a result, many important discoveries were made, especially about the composition of the upper atmosphere and the nature of the radiation that constantly strikes the atmosphere and Earth from the Sun and the far reaches of space.

The information that was obtainable using sounding rockets, such as the German V-2 and its U.S.-built successors, was severely limited because of the short duration of the flights and the fact that they were almost always launched on essentially vertical trajectories. Many scientists were excited by the possibility that a rocket could be made powerful enough and could be controlled precisely enough to place an instrument package into orbit around Earth. The so-called "long playing rockets" could potentially serve as monitors of radiation from the Sun, as a means of determining the precise gravitational and magnetic characteristics of Earth and much more.

The potential of satellites for providing important data about Earth was recognized soon after the results of sounding rockets became available in the early 1950s. When plans for the International Geophysical Year (IGY—July 1957–December 1958) were made, the United States announced that a team of scientists and engineers at the Naval Research Laboratory would undertake to modify their Viking sounding rocket and use it to launch a satellite for scientific purposes. The effort was called Project Vanguard. Soon thereafter the Soviet Union announced that it too would attempt to launch a satellite sometime during the IGY.

The Soviet Union did launch the world's first artificial satellite on October 4, 1957. The United States launched its first successful satellite on January 31, 1958. As is often the case in science, once the new frontier of space was opened to observation and study, important and unexpected discoveries followed almost immediately.

Time and space do not permit description of all the impressive accomplishments of the unmanned satellites and space probes. The most recent information about other planets has come to us from the Voyagers and Venera spacecraft. They follow many earlier successes, highlights of which are included in the following table. ■

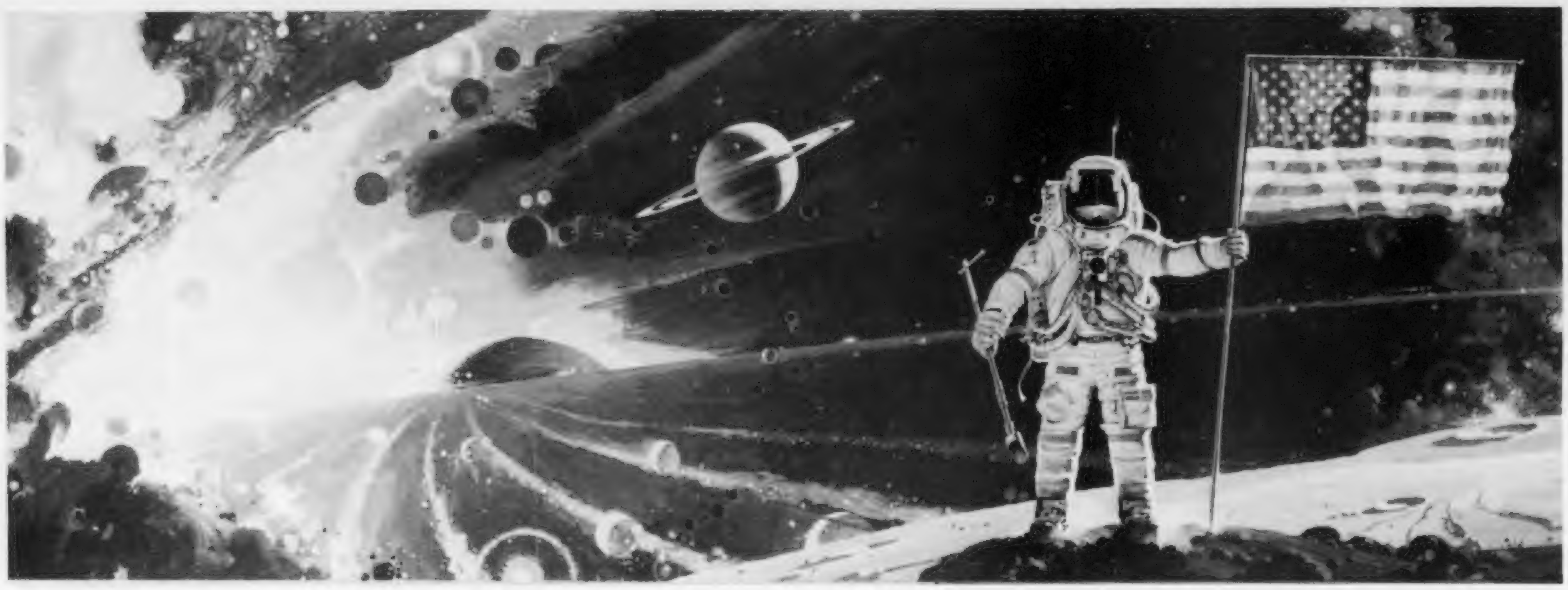
Martian sunset over Chryse Planitia was photographed on August 20, 1976, by Viking 1. The camera began scanning the scene from the left about 4 minutes after the Sun had dipped below the horizon continuing for 10 minutes and covering 120 degrees from left to right. The Sun had set nearly 3 degrees below the horizon by the time the picture was completed.

Major Unmanned Space Firsts of the United States and the USSR

Excerpted from *NASA Pocket Statistics*

Launch	Mission	Description
4 Oct 57	Sputnik 1 (USSR)	Man Made Earth Satellite
1 Feb 58	Explorer 1 (USA)	First successful U.S. satellite with Explorer 3 leads to discovery of Van Allen Radiation Belts
17 Mar 58	Vanguard 1 (USA)	Solar Cells on Spacecraft Earth Shape Measured
14 May 58	Sputnik 3 (USSR)	Orbiting Geophysical Lab
2 Jan 59	Luna 1 (USSR)	Escaped Earth's Gravity
17 Feb 59	Vanguard 2 (USA)	Earth Photo from Satellite
12 Sept 59	Luna 2 (USSR)	Lunar Impact
4 Oct 59	Luna 3 (USSR)	Lunar Picture (Dark Side)
7 Mar 62	OSO-1 (USA)	Orbiting Solar Observatory
26 Aug 62	Mariner 2 (USA)	Interplanetary Probe—Venus Flyby
1 Nov 62	Mars 1 (USSR)	Mars Flyby
28 Jul 64	Ranger 7 (USA)	Close-up Lunar Pictures
28 Nov 64	Mariner 4 (USA)	Mars Fly by Pictures
16 Nov 65	Venera 3 (USSR)	Venus Impact
31 Jan 66	Luna 9 (USSR)	Lunar Soft Landing & Pictures from Surface
31 Mar 66	Luna 10 (USSR)	Lunar Orbiter
30 May 66	Surveyor 1 (USA)	Controlled Lunar Soft Landing
10 Aug 66	Orbiter 1 (USA)	Lunar Pictures from Orbiter

Launch	Mission	Description
17 Apr 67	Surveyor 3 (USA)	Lunar Surface Sampler
7 Dec 68	OAO-2 (USA)	Pointed-Stabilized Orbiting Astrophysical Observatory
17 Aug 70	Venera 7 (USSR)	Venus Soft Landing
12 Sept 70	Lunar 16 (USSR)	Unmanned Lunar Landing & Return of Samples
10 Nov 70	Lunar 17 (USSR)	Unmanned Lunar Roving Vehicle
12 Dec 70	Explorer 42 (USA)	Orbiting X-ray Satellite
19 May 71	Mars 2 (USSR)	Mars Impact
28 May 71	Mars 3 (USA)	Unmanned Mars Soft Landing
30 May 71	Mariner 9 (USA)	Spacecraft in Mars Orbit
3 Mar 72	Pioneer 10 (USA)	Traversed Asteroid Belt Jupiter Probe—Returned Pictures Photos of Jupiter's Moons Will be 1st Man-made Object to Escape the Solar System
21 Aug 72	OAO-C (USA)	Unmanned Astronomical Telescope
6 Apr 73	Pioneer 11 (USA)	Saturn Probe
3 Nov 73	Mariner 10 (USA)	Spacecraft Used Planetary Gravity Assist to Encounter Two Planets (Venus and Mercury) Flyby TV Pictures of Venus Identify Venus Atmosphere Flyby TV Pictures of Mercury Identify Mercury Atmosphere Four Planetary Encounters on Single Mission—One to Venus and Three to Mercury
8 Jun 75	Venus 9 (USSR)	Spacecraft in Venus Orbit Photograph from Venus Surface
20 Aug 75 9 Sept 75	Vikings 1&2 (USA)	Multiday Operation of Spacecraft on Surface of Another Planet In-situ analysis of surface material and biological experiments conducted on another planet
20 Aug 77	Voyager 2 (USA)	Detailed pictures of Jupiter and its moons Detailed pictures of Saturn and its moons Trajectory to encounter Uranus and Neptune



The Space Mural—A Cosmic View
Robert McCall
Acrylic on canvas, 1976
© Smithsonian Institution, 1976

Space Art: 100 Years Of Space Exploration

William K. Hartmann
Senior Scientist
Planetary Science Institute
Science Applications International

In the the last century, as humans explored the frontiers of our globe, artists such as Thomas Moran and Albert Bierstadt traveled with geological and geographical expeditions to paint exciting and sublime vistas that they encountered in the American West. American painter Frederick Church even outfitted his own expeditions to paint jungles and erupting volcanoes in South America and the Northern Lights over the Arctic Ocean. Their commitment to painting nature led these artists to seek the awesome. The paintings that they brought back from the wilderness stimulated the imaginations of people "back home" and contributed to the awareness of the American frontier.

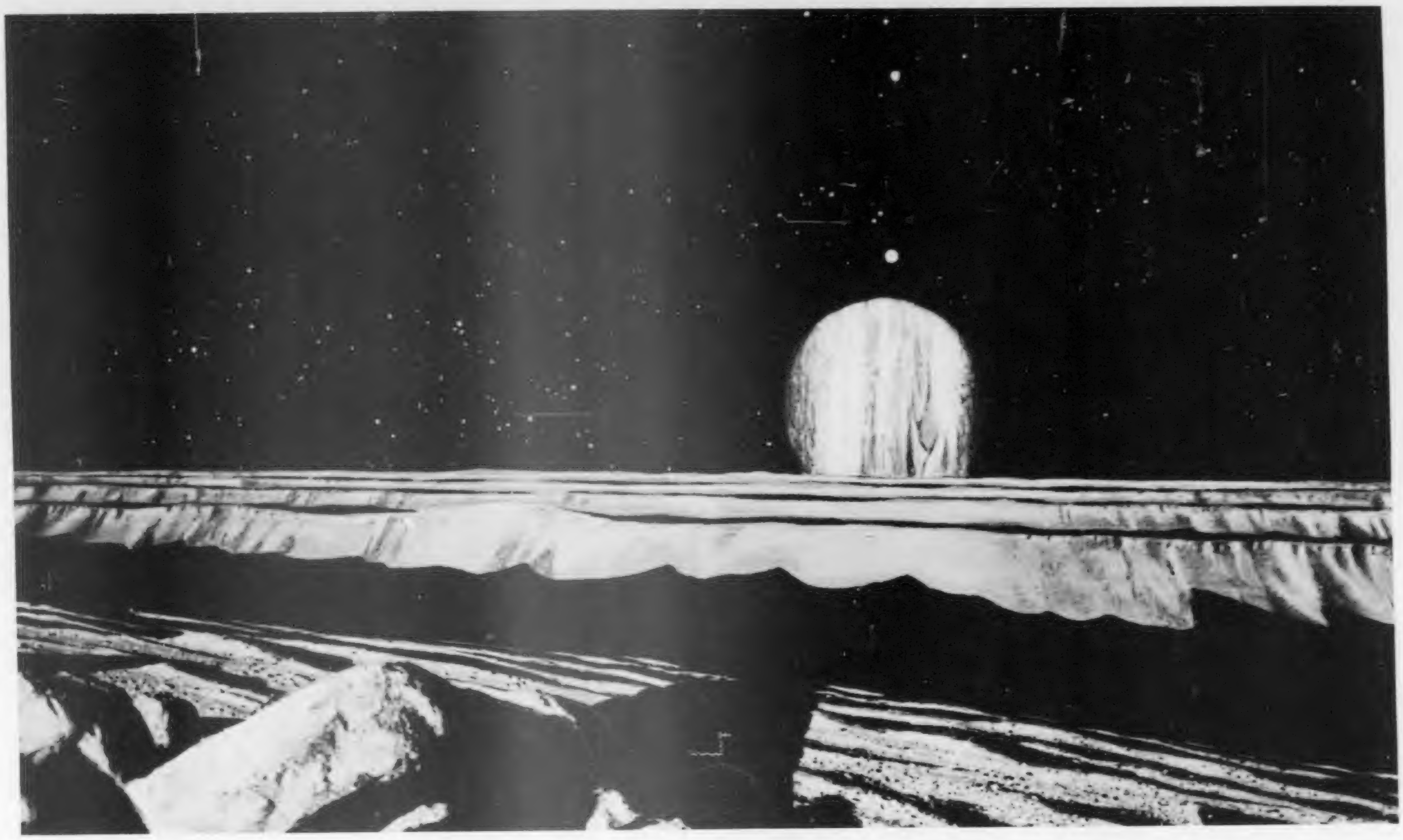
Today, as our space vehicles explore the planetary frontier, it might seem that space-probe photographs play the same role as last century's artists, showing the people "back home" what is "out there." However, there is one major difference. Whereas the pioneer artists sought spectacular vistas, such as views of the Yellowstone region, Devil's Tower, the Grand Canyon, and the High Sierras, spacecraft photos bring back a random sample of views dependent upon their trajectories. In fact, in the case of lunar-astronaut and Martian-landing photos, the visited regions are among the dullest places offered by each planet, because the landing sites were deliberately chosen for their relatively smooth terrain. There are grand vistas on Mars that we still have not seen, as we now know from the complete series of orbital mapping photographs, which show "aerial" views of enormous volcanoes, deep canyons, chaotic-collapsed terrain, landslides, and dry river beds.

Artists are less limited than space vehicles in their travels through the Solar System. Armed with facts and photos, they can ferret out the magnificent. The space exploration program has produced public enthusiasm, and among the most enthusiastic are these artists whose work is only beginning to be recognized.

Their subject matter is tied together through their common inspiration of exploration beyond Earth. The range of styles is highly varied and develops in many directions and fields of artistic expression. At one end of the spectrum are artists who use rigorously accurate scientific information to portray in a realistic but dramatic way the impressive vistas of other planets and interplanetary space. Their work involves highly realistic paintings that might be referred to as "astronomical art." This genre grades imperceptibly into more hypothetical paintings that might show, for example, imaginary space vehicles or colonies of the future—but rendered with informed scientific accuracy. The next genre delves into what might be called "science fiction illustration" where realistic or even nonrealistic planetary backgrounds may be used for action pictures, book covers, and even great heroic murals like Robert McCall's in NASM's lobby. In quite a different direction lie impressionist and abstract paintings inspired by rocket launches and by space exploration.

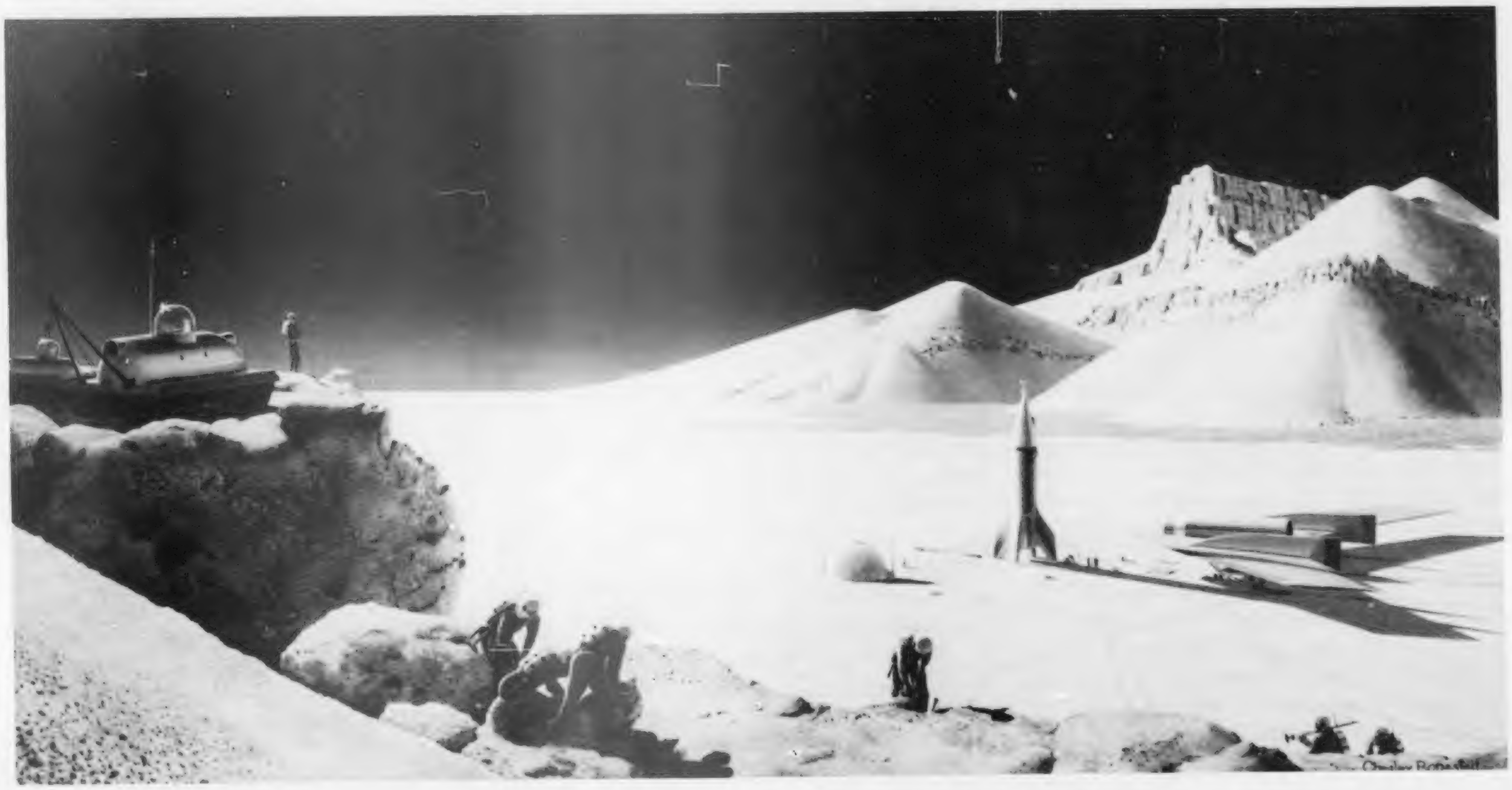
Since the early years of manned space flights, NASA has run an art program in which artists are given access to launch facilities and are commissioned to produce paintings based on their experiences. Major collections of these paintings can be seen in NASM's art gallery and at NASA centers nationwide. These paintings have been collected in a book entitled *Eyewitness to Space* by the late H.L. Cooke, Curator of Painting, National Gallery of Art, and James Dean, former Curator of Art, NASM (New York: Harry N. Abrams, Inc., 1971). The paintings range from realistic views of astronauts and facilities by artists such as Norman Rockwell and James Wyeth to abstract works by Yeffe Kimball and others. These works, however, are reactions to what has occurred on Earth.

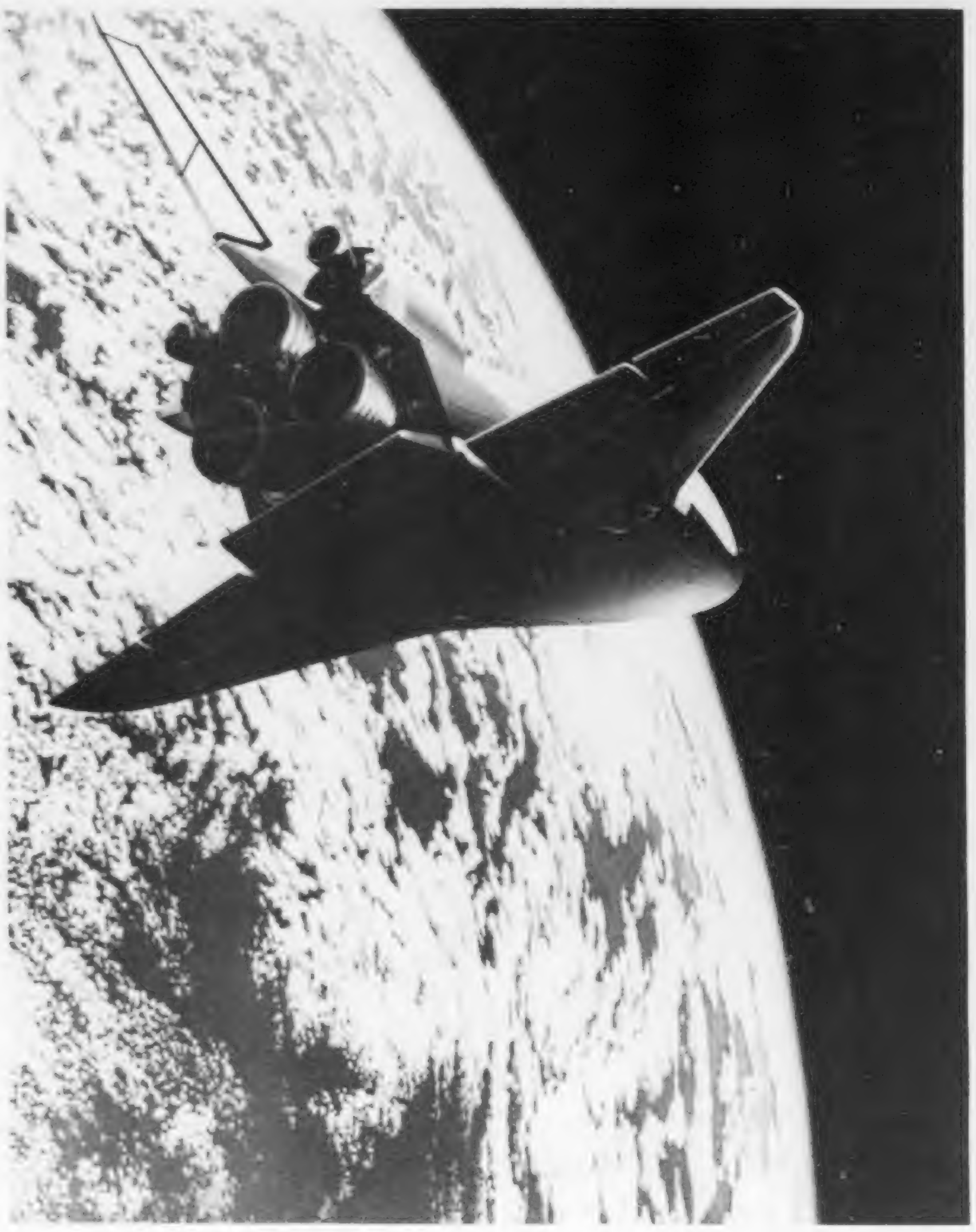
The paintings of several centuries have focused within the confines of planet Earth. How much more among the many dozens of other planetary bodies in the Solar System is there to inspire us? In 1978, artist Ron Miller produced a book entitled *Space Art* in which he not only presented the works of many new artists but also traced the "archeology of space art" back to 1865 when illustrations for Jules Verne's novels began to attempt depiction of space marvels on a scientific basis. For example, Verne's 1877 book *Off on a Comet,* showed scenes of Jupiter and its moons as seen from a passing asteroid.



Grooved Terrain
© Ron Miller
Acrylic on board, 1980
Virginia artist Ron Miller has published book covers and story and technical illustrations in magazines such as Science 82 *and also recently collaborated with Hartmann on a book,* The Grand Tour: A Traveller's Guide to the Solar System, *containing text and paintings like this one. Miller used Voyager discoveries of grooved or fissured terrain on Jupiter's satellite Ganymede to envision this view across the grooves toward Jupiter and two of its other moons (above). The Sun is behind us.*

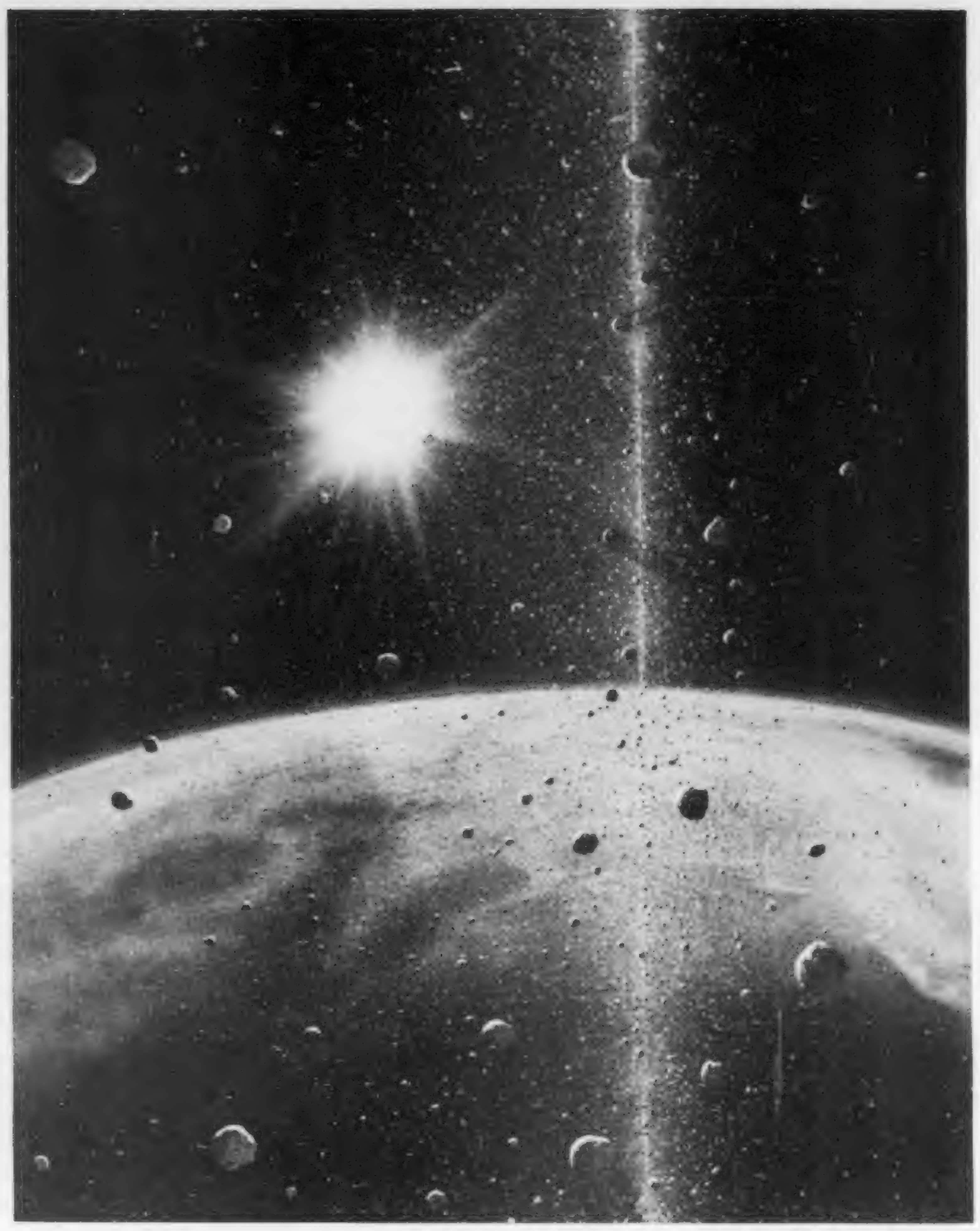
Exploration of Mars
© Chesley Bonestell
Oil on canvas, 1955
This is one of 16 color paintings that appear in The Exploration of Mars *by Willy Ley and Wernher von Braun with Chesley Bonestell. Bonestell projects into the future to show us this scene of men exploring the planet Mars. The ground station has been set up on Mars, and the explorers are beginning to investigate the vicinity of the landing site. "The scene before them might well be a desert region in the American Southwest, glistening in the sunslight under a dark blue, cloudless sky" (from* The Exploration of Mars*).*





Space Shuttle in Flight
Pamela Lee
Acrylic on board, 1980

Pamela Lee has produced many astronomical paintings that have a special sense of color and luminosity. This dramatic composition lends a sense of adventure to this view of the space shuttle maneuvering in orbit above Earth.



In Saturn's Rings
© William Hartmann
Acrylic on board, 1980

Data from Voyagers and ground-based telescopes show that Saturn's rings are made of drifting ice chunks of baseball or basketball size. Here we drift in a moderately populated region, surrounded by floating hailstones backlit by the sun [upper left center]. The cloud-mottled surface of Saturn is below.

Miller identifies two major figures who might be called the grandfather and father of space art. The grandfather was Lucien Rudaux (1874–1947), a French astronomer and also an artist. In a moderately free and painterly style, with the greatest accuracy that he could muster, Rudaux made many paintings of the surfaces of the Moon and planets. Among all the pre-Apollo space artists, Rudaux has the distinction of perhaps painting the most realistic depictions of the gently rounded mountains of the Moon. He even complained explicitly about the craggy pinnacles that other contemporaries depicted on the Moon. Apparently these artists were influenced by telescopic views and photographs of the Moon under very low Sun angles, which exaggerated the apparent roughness of its surface. Rudaux realized that the actual profiles of the lunar mountains (as seen on the limb of the Moon through a telescope) were more rounded than the spiky shadows that they cast at sunrise and sunset.

If Rudaux was the grandfather of space art, the father is certainly Chesley Bonestell (b. 1888). As a youngster in California, Bonestell visited newly established observatories where astronomers allowed him some fateful glimpses of the planets. Later, as an architectural artist in London in the 1920s, Bonestell was exposed to space wonders in magazine illustrations by Rudaux and others. Bonestell was both well-trained and gifted in geometric perspective and rapidly developed into a painter of great imagination and presence. Bonestell's interest in space art flowered in the 1940s, when he was working as the highest paid matte artist in Hollywood films. During this period, when he prepared background shots for films such as *The Hunchback of Notre Dame* and *Citizen Kane*, Bonestell published a series of paintings of Saturn as seen from its different satellites in *Life* magazine. He later collaborated on an epochal book with Willy Ley entitled *The Conquest of Space.* It is astonishing to discover how many of today's planetary scientists, NASA engineers, and other researchers and technicians trace their first excitement about space exploration back to this book.

About 1950, Bonestell illustrated a series of articles and books published by *Collier's* magazine detailing, with authors such as Werner von Braun, how space exploration might proceed. Many of these paintings are still prophetic, showing winged shuttle-like vehicles floating near mighty wheel-shaped space stations. Bonestell's paintings are among the most realistic and dramatic astronomical paintings ever made; yet they are not without a sense of humor. In one view across the lunar crater Copernicus, a foreground astronaut excitedly beckons his friends to see a discovery: Chesley Bonestell's signature chisled in a lunar rock!

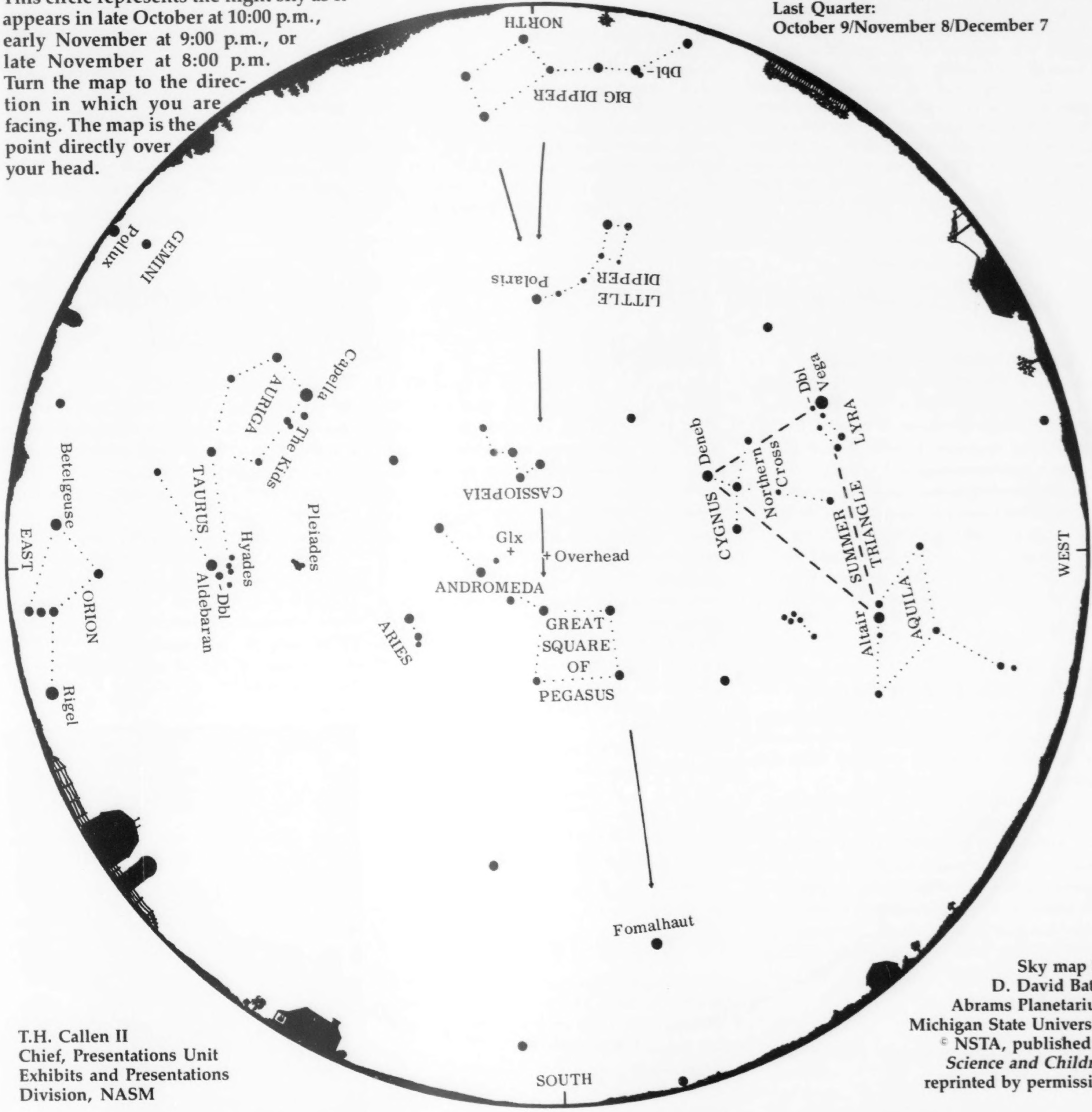
Bonestell still goes to his studio to paint a revised planetary landscape when new spacecraft photographs come in, and he still has a bright twinkle in his eye as he criticizes the work of any *other* artist who might have the temerity to attempt painting an extraterrestrial scene. After all, Bonestell staked out most of those claims many years ago!

The success and influence of Bonestell's work particularly demonstrates the subliminal effect that space artists can have on space exploration. Scientists are trained to reduce their knowledge to numbers, but it is a picture that synthesizes these numbers from many different fields into a single visual conception that has immediate impact upon the brain. And it is a picture that can convey the emotions of awe and excitement. Such emotions are at the root of our space exploration efforts. ■

Fall 1982 Sky Map

This circle represents the night sky as it appears in late October at 10:00 p.m., early November at 9:00 p.m., or late November at 8:00 p.m. Turn the map to the direction in which you are facing. The map is the point directly over your head.

PHASES OF THE MOON
New Moon:
October 17/November 15/December 15
First Quarter:
October 25/November 23/December 23
Full Moon:
October 3/November 1/December 1 and 30
Last Quarter:
October 9/November 8/December 7


NORTH
Dbl
BIG DIPPER
GEMINI
Pollux
Polaris
LITTLE DIPPER
Capella
AURIGA
The Kids
Betelgeuse
TAURUS
Hyades
Pleiades
EAST
ORION
Dbl
Aldebaran
Rigel
CASSIOPEIA
Glx
+ Overhead
ANDROMEDA
ARIES
GREAT SQUARE OF PEGASUS
Deneb
Dbl
Vega
LYRA
Northern Cross
CYGNUS
SUMMER TRIANGLE
Altair
AQUILA
WEST
Fomalhaut
SOUTH

Sky map by
D. David Batch
Abrams Planetarium
Michigan State University
© NSTA, published in
Science and Children
reprinted by permission

T.H. Callen II
Chief, Presentations Unit
Exhibits and Presentations
Division, NASM

Our sky map for fall 1982 finds us with two geometric shapes on opposite sides of the zenith, the point directly overhead. To the west is the unofficial grouping called the Summer Triangle, made of the three brightest stars of three smaller, officially recognized constellations: *Cygnus,* the Swan (Deneb), *Lyra,* the Harp (Vega), and *Aquila,* the Eagle (Altair).

To the eastern side of the zenith we find the Great Square of *Pegasus*, the Flying Horse. According to classical mythology, Pegasus was the pure white steed of Perseus, the Champion. The winged wonder was created when Perseus slew the Medusa. As her decapitated head tumbled to the ground, Pegasus sprang from the spattering blood. While traditionally we are to see a flying horse in this part of the night sky, many people see a baseball diamond made from the Great Square. Holding your sky map so that the southeast direction is straight down as you look at the map, home plate is marked by the lower star, first base by the star to the right, second base by the upper star, and third base by the last of the four.

Take your sky map outdoors on a clear fall evening and see if you can find the third base of the baseball diamond we just made from the Great Square of *Pegasus*. If you look carefully you will see a double string of stars streaming off toward the northeast. These two strings form a skinny "V," with the star we've called third base (it's real name is Alpheratz) as their joining point. This is the constellation of *Andromeda,* the Chained Maiden, later the wife of Perseus who rescued her from a sea monster with Pegasus' help. Many people think she looks more like a hunting horn or the horn of plenty—the cornucopia—than a beautiful young woman.

There is a small "+" marked "Glx" on the star map between *Andromeda* and *Cassiopeia,* the Queen (who also happens to be the maiden's mother). Seen as a faint, elongated sliver of light in the real sky, our charted object (Glx) is the Great Andromeda Galaxy, also known as M 31 for it is the 31st object on Charles Messier's famous list of celestial objects. It is easy to go to a standard astronomy textbook and note that at its distance of 2.2 million light years (19×10^{18} km or 13×10^{18} mi.), the Andromeda Galaxy is the farthest object you can see with the unaided eye. But when, in fact, was it first noted by such an eye and recorded?

According to R.H. Allen's *Star Names: Their Lore and Meaning* (Dover Publications, Inc.), the Andromeda Galaxy was known as far back in recorded history as A.D. 905. The Persian astronomer Al Sufi described it as a "Little Cloud" in the latter half of the 10th Century A.D., though it wasn't until A.D. 1500 that M 31 could be found on a Dutch star map. Its next apparent appearance in literature occurs in Simon Marius' rare edition *De Mundo Joviali* where the author says he examined it by telescope on December 15, 1612. Marius describes its feeble glow through his telescope as resembling "the light of a candle shining through horn." Through small optical instruments, the Andromeda Galaxy does look like this light. Curiously, Marius did not try to claim discovery of this object as he supposedly did for Jupiter's satellites, which Galileo had actually located about two years earlier. We have, however, adopted Marius' names for the Galilean satellites: "Io, Europa, Ganymede, and Kallisto." Sir Edmund Halley of comet fame claimed the honor of discovering M 31 in 1661, though he did mention that the object had been observed 150 years earlier by an unknown but talented astronomer.

Astronomers Hevelius and Flamsteed both included M 31 in their catalogs, while Ptolemy, Tycho Brahe, and Bayer did not. What led to the discrimination of such an obvious object is unknown.

With the advent of larger telescopes, our perception of this fuzzy spindle of light in *Andromeda* has changed dramatically, from a soft glow of light believed to be part of the Milky Way to a vast stellar system outside it. The light we see today on clear fall evenings left the Andromeda Galaxy when our ancestors were still exploring their grassland surroundings over two million years ago. ■

NASM Fellowships and Internships

Guggenheim Fellowship

This is a one-year resident fellowship for pre- or postdoctoral research. Scholars interested in research related to the history of aerospace science and technology are encouraged to apply.

Minimum academic requirements:

a. Pre-doctoral: bachelor's degree and current enrollment in an accredited college or university

Postdoctoral: PhD degree preferably received within the past two years

A. Verville Fellowship

The National Air and Space Museum has established a fellowship in honor of Alfred V. Verville, a noted aviation designer.

A competitive nine-to-twelve month fellowship is intended for the analysis of major trends, developments, and accomplishments in aviation or space studies. The fellowship is open to all interested candidates who can provide a critical analytical approach to such studies and possess good writing skills. An advanced degree is not a requirement.

Applications and proposals due by: **January 15, 1983**

For more information on the Guggenheim Fellowship and/or the A. Verville Fellowship, write:

National Air and Space Museum
Room P-700
Washington, D.C. 20560
Tel: (202) 357-1504

Photo Credits: Cover, pages 5-11 and 14: courtesy NASA; Page 4: courtesy *Sky and Telescope* magazine; Page 3: courtesy Smithsonian Institution Astrophysical Observatory; Page 14 and 15 (bottom): courtesy NASM; Page 15 (top) and page 16: courtesy of the artist.

Internships

Internships are offered quarterly at NASM to undergraduate and graduate students studying museology, history, aviation, space science, and education. Projects are tailored to the individual's background, and each student is assigned to one department of the Museum under the supervision of staff members. Intern appointments are available for six weeks to one year. A maximum stipend of $150 per week is given based on the educational experience of the applicant. Credit may be earned in some cases. Check with your placement office.

For more information on internships write:

Internship Program
National Air and Space
Museum
Room P-700
Washington, D.C. 20560
Tel: (202) 357-1504

Attention educators!

Air & Space magazine's circulation list is open for new subscribers. Interested educators should send requests on official school stationary to:

Air & Space
Room P-700, Education Services Division
National Air and Space Museum
Smithsonian Institution
Washington, D.C. 20560

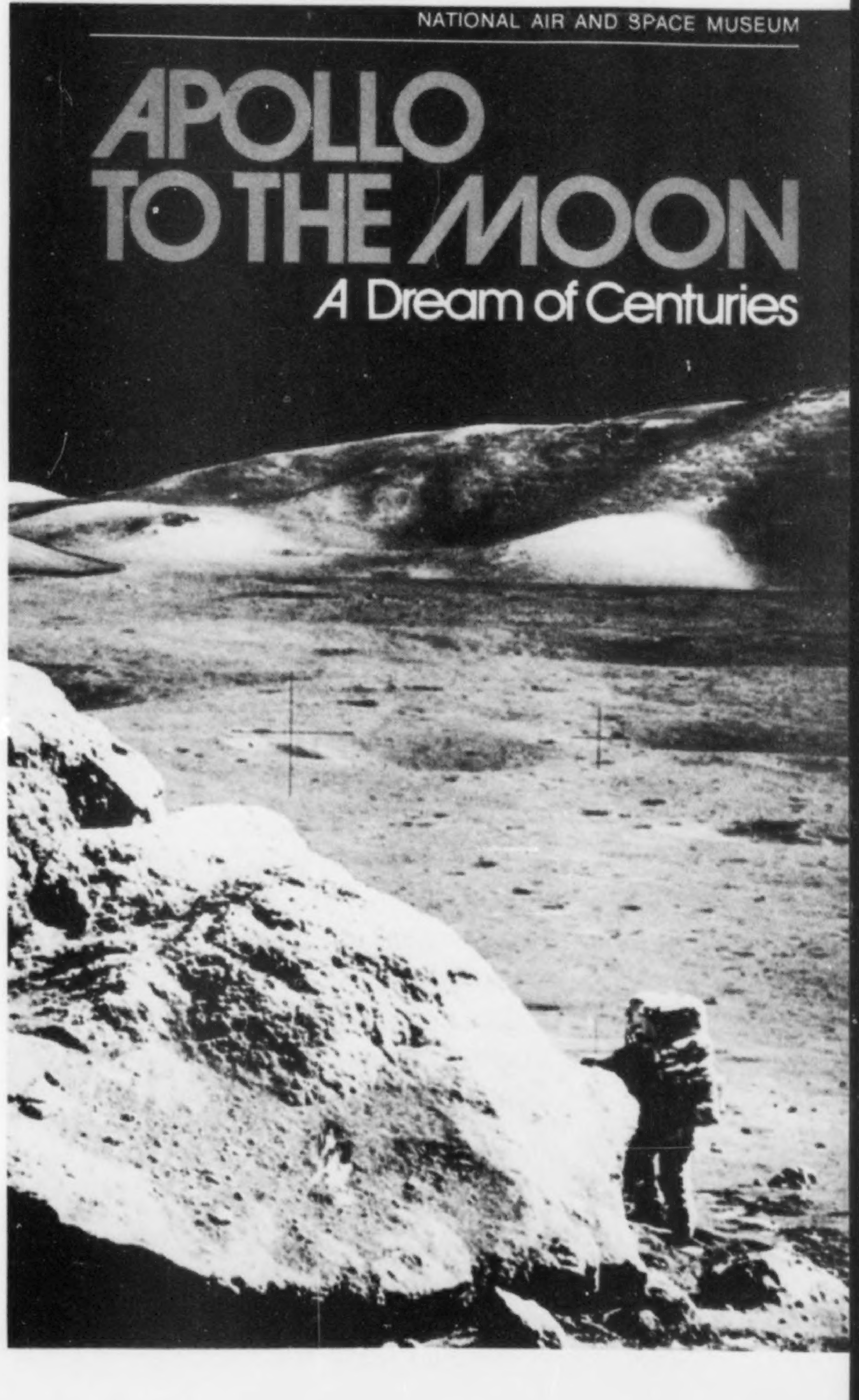
New Tour

To commemorate the past 25 years of space exploration and to help visitors enjoy the Museum's extensive collection of spacecraft, a self-guided tour has been developed. Free copies of the tour guide are available at the Information Desk in the Museum's South Lobby.

New Publication from NASM

NASM's third exhibition booklet, *Apollo to the Moon: A Dream of Centuries,* traces the U.S. space program from the launch of the first U.S. satellite, Explorer 1 in 1958, through the Apollo program years in the 1960s, to the launch of *Columbia*, the first Space Shuttle in April 1981. The guide features spectacular color photographs of various space missions, photographs of Apollo artifacts currently on exhibit at NASM, as well as a detailed text discussing man's long-time fascination with the universe.

Apollo to the Moon is currently on sale at NASM's Spacearium and Museum shops for $2.75.



Regional Resource Program

A NASM outreach, the Regional Resource Persons Program is designed to prepare educators to give presentations in their respective geographic regions on major aerospace developments as exhibited in the Museum's galleries and special activities. NASM provides Regional Resource Persons (RRPs) with support material such as slides, catalogs, and selected publications, plus limited public relations assistance. Persons interested in participating should contact Janet K. Wolfe, Chief, Education Services Division, NASM, Smithsonian Institution, Washington, D.C. 20560, (202) 357-1504, or one of the following RRPs may be contacted.

NORTHEAST

Connecticut
Salvatore Polio
19 Hampton Road
Hamden, CT 06518

District of Columbia
Norman O. Poff
NASA Headquarters
Mail Code L5G19
Washington, D.C. 20546

Maryland
Sherman Taffel
1300 West 36th Street
Baltimore, MD 21211

Massachusetts
Marilyn J. Burysz
25 Trudy Terrace
Brockton, MA 02401

Richard Little
3 Plain Street
P.O. Box 52
N. Abington, MA 02351

New Jersey
Walter Dinteman
200 Tenby Chase Drive
Delran, NJ 08075

Stanley A. Fisch
300 Merrison Street
Teaneck, NJ 07666

Thomas J. Flieger
47 Carol Road
Middletown, NJ 07748

Mary Ellen F. Flynn
38 Echohill Lane
Willingboro, NJ 08046

New York
Eugene S. Berlin
2244 East 26th Street
Brooklyn, NY 11229

Harvey L. Flissser
10 Lockwood Road
Scarsdale, NY 10583

Sam Garry
14702 29th Avenue
Flushing, NY 11345

Dinah L. Moche
130 Teresa Lane
Mamaroneck, NY 10543

Robert J. Ullery
4 Abedar Lane
Latham, NY 12110

Pennsylvania
Fred Hofkin
8212 Aspen Way
Elkins Park, PA 19117

Paul W. Hornack
P.O. Box 442
Boalsburg, PA 16827

William B. McIlwaine
53 Brenner Street
Millersville, PA 17551

John Zuchero
170 Oak Street
Gilbertsville, PA 19525

SOUTH

Alabama
Heather C. Comer
P.O. Box 788
Daphne, AL 36526

Florida
Tom Anderson
Visitor Center, TWA-840
Kennedy Space Center, FL 32899

Dr. Edward Reichback
Florida International Univ.
Miami, FL 33199

Thomas J. Sarko
2974 Kirk Road
Lake Worth, FL 33461

Georgia
Ted Colton
550 Cheryl Lane
Kennesaw, GA 30144

Carol G. Hickson
796 Centridge Drive
Atlanta, GA 30306

Elizabeth A. Parmalee
1260 Thomas Circle
Roswell, GA 30075

Dr. Ernest D. Riggsby
Columbus College
Columbus, GA 31907

John R. Stephens, Jr.
P.O. Box 1021
Athens, GA 30603

North Carolina
Bob Armbrust
500 Hickory Road
Goldsboro, NC 27530

Connie S. Bright
207 Steward Lane
Greenville, NC 27834

Dr. Vijay S. Joshi
Durham Technical Institute
P.O. Box 11307
1637 Lawson Street
Durham, NC 27703

Tennessee
Laverne S. Dinwiddie
114 North Holmes Street
Memphis, TN 38111

Etta Williams
2911 Willow Brook Drive
Nashville, TN 37211

Virginia
Taz Daughtrey
736 Sanhill Drive
Lynchburg, VA 24502

Virginia Ellett
56 Lock Lane
Richmond, VA 23226

MID-WEST

Illinois
Sister Jean M. Kaindl
8001 Belmont Avenue
River Grove, IL 60171

Paul D. Van Proyen
1418 Western
Champaign, IL 61820

Indiana
Francis A. Hughes
R. R. 14, Box 81
Columbus, IN 47201

James O. Yarber
RRI Box 210 T
Fountaintown, IN 46130

Iowa
Jean P. Beard
5612 Linden Circle
Des Moines, IA 50324

Michigan
Robert N. McCullough
15145 180th Avenue
Big Rapids, MI 49307

Daniel J. Tuzinowski
3540 Chicago Road
Warren, MI 48092

Minnesota
Barbara Hicks
14969 Manitou Road
Prior Lake, MN 55372

Dr. Hope E. Bouvette Issacson
4144 Browndale
Minneapolis, MN 55416

Bruce Tollefson
415 N.E. 5th Street
Staples, MN 56479

Daniel Whipple
11726 Norway Street, N.W.
Coon Rapids, MN 55433

Missouri
Mark E. Ingram
P.O. Box 16, Route 2
Purdy, MO 65734

Wayne Mosher
St. Louis Metro Teacher Center
9137 Old Bonhomme
St. Louis, MO 63132

Montana
Dorothy K. Curtis
909 North 32nd Street
Billings, MT 59101

Patricia B. Johnson
514 Leslie Avenue
Helena, MT 59601

Nebraska
Florence Boring
2836 South 40th Street
Lincoln, NB 68506

North Dakota
Donald Uhlenberg
2810 Belmont
Grand Forks, ND 5820

Ohio
G. Courtney Chapman
488 Greenglade Avenue
Worthington, OH 43085

Phillip R. Chatwood
9088 Monroe Central Road
West Manchester, OH 45505

John L. Lilley
164 N. Prospect Street
Kent, OH 44240

WEST

Texas
Henrietta Blend
3310 Cummins Lane
Houston, TX 77027

John Eslinger
3709 Line Avenue
Amarillo, TX 79106

William Joseph Lex
909 East 43rd Street
Austin, TX 78751

WEST-COAST

California
Stephen Lattanzio
22601 Marylhurst Court
El Toro, CA 92630

Kenneth Kay Selee
2100 Loyola Way
Turlock, CA 95380

Oregon
Robert F. Wendel
13700 S.W. Burlwood
Beaverton, OR 97005

Washington
Moy R. Midkiff
418 N. Percival
Olympia, WA 95802

NEW
From the National Air and Space Museum
of the Smithsonian Institution . . .

A unique series of soundstrips exploring the science, history, technology, and social impact of aviation and space exploration.

Aerospace achievement comes to life in titles like:
- Apollo to the Moon
- Milestones of Flight
- Balloons and Airships
- World War II Aviation
- Rocketry and Space Flight

An illustrated booklet describing the entire collection of 21 dramatic programs—which trace the world's eternal fascination with flight—is available now. To obtain your **FREE** copy write to the address listed below. Please indicate elementary or secondary level.

National AudioVisual Center
National Archives and Records
Service
General Services Administration
Reference Section EH
Washington, DC 20409
. . . or call (301) 763-1896

National AudioVisual Center
. . . a public service
of your government

flight

National Air and Space Museum
Smithsonian Institution
Washington, DC 20560
Room P-700

Non-Profit Org.
U.S. Postage
Paid
Permit #3361
Baltimore, Md.

800455

JOYCE BROWN
SERIALS DEPARTMENT
UNIV. MICROFILMS INTERNATIONAL
300 N. ZEEB ROAD
ANN ARBOR, MI 48106